

**FINAL GEOTECHNICAL DATA REPORT
COLLIER RAW WATER PUMP STATION AND TUNNEL
CITY OF BEAUMONT
BEAUMONT, TEXAS**

Prepared for:

**Freese and Nichols, Inc.
11200 Broadway Street, Suite 2320
Pearland, Texas 77584**

Prepared by:

**Tolunay-Wong Engineers, Inc.
2455 West Cardinal Drive, Suite A
Beaumont, Texas 77705**

July 22, 2021

TWE Project No. 21.23.014 / Report No. 120334

Tolunay-Wong Engineers, Inc.

2455 West Cardinal Drive, Suite A • Beaumont, Texas 77705 • Phone: (409) 840-4214 • www.tweinc.com

July 22, 2021

Freese and Nichols

11200 Broadway Street, Suite 2320
Pearland, Texas 77584

Attn: Mr. Somnath Chilukuri, P.E.
Somnath.Chilukuri@freese.com

Ref: Final Geotechnical Data Report
Collier Raw Water Pump Station and Tunnel
City of Beaumont
Beaumont, Texas
TWE Project No. 21.23.014 / Report No. 120334

Dear Mr. Chilukuri,

Tolunay-Wong Engineers, Inc. (TWE) is pleased to submit this final geotechnical data report of our geotechnical investigations performed for the referenced project. This final report contains a detailed description of the field and laboratory work performed for this study, test boring logs with tabulated field and laboratory test results, individual laboratory test reports and electrical resistivity survey data.

We appreciate the opportunity to provide this final factual report for this project. If you have any questions regarding this factual report or if we can be of further assistance, please contact us.

Sincerely,

TOLUNAY-WONG ENGINEERS, INC.

TBPELS Firm Registration Number F-000124



Mariam Abdelwahab, E.I.T.
Staff Geotechnical Engineer

MA/TGH/ma



Tyler G. Henneke, P.E.
Vice President

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1 INTRODUCTION AND PROJECT DESCRIPTION

1.1 Introduction

This report presents the results of our geotechnical investigations performed for the Collier Raw Water Pump Station and Tunnel in Beaumont, Texas. Our scope was performed in general accordance with TWE Proposal No. P21-015 (Revision 1) dated January 14, 2021 and authorized by issuance of Freese and Nichols, Inc. Subconsultant Authorization dated January 20, 2021.

1.2 Project Description

The project includes various components associated with the City of Beaumont Flood Improvement Project. We understand the components are associated with final design of the proposed Collier Raw Water Pump Station (RWPS) and an influent tunnel connection to the existing Lawson Pump Station facility. Redacted project information, as provided by the Client (FNI) in a Preliminary Geotechnical Investigation Plan document, is presented in Appendix A of this report.

2 PURPOSE AND SCOPE OF SERVICES

The purposes of our factual geotechnical investigations were to investigate the subsurface soil and groundwater conditions within the project alignment and to provide our Client factual geotechnical information for use as the basis of their design and construction assessments. Our scope of services included:

1. Conducting thirteen (13) test borings (TBs), installing three (3) temporary standpipe piezometers (PZs) with associated slug testing and performing seven (7) electrical resistivity surveys (ERSs) to evaluate subsurface stratigraphy, groundwater conditions and apparent electrical resistivity within the project alignment;
2. Performing geotechnical laboratory tests on recovered soil samples from the test borings to evaluate the physical and engineering properties of the strata encountered; and,
3. Providing gINT boring logs compiled from the field and laboratory data as well as individual laboratory test reports.

Our scope of services did not include development of geotechnical design parameters, engineering analyses or any environmental assessments for the presence or absence of wetlands or of hazardous or toxic materials within or on the soil, air or water within the project alignment. Any statements in this report or on the boring logs regarding odors, colors, unusual items and conditions are strictly for the information of the Client. A geological fault study, geophysical explorations and development of geotechnical design and construction recommendations were also beyond our factual scope.

3 FIELD PROGRAM

TWE conducted explorations of subsurface soil and groundwater conditions within the project alignment from February 8, 2021 to March 11, 2021. The scope of the field program included drilling, logging, sampling and backfilling thirteen (13) test borings (TBs), installing three (3) temporary standpipe piezometers (PZs) with associated slug testing and performing seven (7) electrical resistivity surveys (ERSs). Our geotechnical field program performed for the project is outlined in Table 1 below and illustrated on TWE Drawing Nos. 21.23.014-1 through 21.23.014-3 in Appendix B.

Table 3-1: Field Program Summary						
Location	Description	TB Name	TB Depth (ft)	PZ Name	PZ Depth (ft)	ERS Name
1	Lawson PS Shaft	TB-1	40	-	-	ERS-1
2	Lawson PS Site	TB-2	40	PZ-2	40	-
3	Tunnel Sta. 5+00	TB-3	30	-	-	ERS-3
4	Tunnel Sta. 8+00	TB-4	30	-	-	-
5	Tunnel Sta. 11+00	TB-5	30	-	-	ERS-5
6	Tunnel Intermediate Shaft Sta. 13+76	TB-6	35	-	-	-
7		TB-7	35	PZ-7	35	ERS-7
8	Tunnel Sta. 17+00	TB-8	30	-	-	ERS-8
9	Tunnel Sta. 20+00	TB-9	30	-	-	-
10	Tunnel Sta. 23+00	TB-10	30	-	-	ERS-10
11	Collier RWPS Shaft	TB-11	50	-	-	ERS-11
12	Collier RWPS Site	TB-12	50	-	-	-
13		TB-13	50	PZ-13	50	-
Total TB Count		13				
Total TB Footage (ft)			480			
Total PZ Count				3		
Total PZ Footage (ft)					125	
Total ERS Count						7

On February 12, 2021, TWE performed boring TB-1 located within the Lawson Pump Station facility. An unknown obstruction was encountered at 28-ft below grade and the boring was terminated. We did not direct our Driller to attempt to advance the borehole since we were unsure of what the obstruction entailed (active or abandoned pipeline or utility that wasn't picked up on the One Call, buried debris, tree stump, etc.). Mud rotary drilling techniques at that depth also made it difficult to provide any context as to what the obstruction may have been.

The Client was notified to provide further instructions for an offset location. On March 2, 2021, TB-1 was offset approximately 10-ft south and 8-ft east from the original location. The boring was shotholed to 28-ft and sampling reconvened from 28-ft below grade to the boring completion depth of 40-ft below grade.

3.1 Test Borings

3.1.1 Drilling Methods

The test borings were performed in general accordance with the Standard Practice for Soil Investigation and Sampling by Auger Borings (ASTM D1452). The test borings were performed using conventional highland buggy-mounted drilling equipment and advanced using dry-auger drilling methods until groundwater was encountered. At that point, the borings were completed using wash-rotary drilling techniques. Samples were obtained continuously on 2-ft intervals to a depth of 30-ft below existing grade and at 5-ft depth intervals thereafter to the boring completion depths. Upon drilling and sampling completion the boring was backfilled with cement-bentonite grout.

3.1.2 Soil Sampling

Fine-grained, cohesive soils and semi-cohesionless soils thought to be cohesive during drilling were recovered from the test boring by hydraulically pushing a 3-in diameter, thin-walled tube a distance of 24-in. The field sampling procedures were conducted in general accordance with the Standard Practice for Thin-Walled Tube Sampling of Soils (ASTM D1587). Our Geotechnician visually classified the recovered soils and obtained field strength measurements of the recovered soils using a calibrated pocket penetrometer and/or hand torvane device. The tube samples were extruded in the field, wrapped in foil, placed in moisture-sealed plastic bags and protected from disturbance prior to transport to the laboratory. The recovered soil sample depths and field strength measurements are shown on the project boring logs in Appendix C.

Cohesive soils thought to be coarse-grained during drilling, as well as cohesionless and semi-cohesionless coarse-grained soils, were collected with the Standard Penetration Test (SPT) sampler driven 18-in by blows from a 140-lb hammer falling 30-in in accordance with the Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils (ASTM D1586). The number of blows required to advance the sampler three (3) consecutive 6-in depths are recorded for each corresponding sample on the boring logs in Appendix C. The N-value, in blows per foot, is obtained from SPTs by adding the last two (2) blow count numbers. The consistency of cohesive soils and the relative density of cohesionless and semi-cohesionless soils can be inferred from the N-value. The samples obtained from the split-barrel sampler were visually classified, placed in moisture-sealed plastic bags and transported to our laboratory. SPT sampling intervals and blow counts are presented on the project boring logs in Appendix C.

3.1.3 Boring Logs

Our interpretations of general subsurface soil and groundwater conditions at the boring locations are included on the gINT project boring logs in Appendix C. The interpretations of the soil types throughout the boring depths and the locations of strata changes were based on visual classifications during field sampling and laboratory testing using the Standard Practice for

Classification of Soils for Engineering Purposes (Unified Soil Classification System) [ASTM D2487] and the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) [ASTM D2488]. A key to the symbols and terms used on boring logs is also included in Appendix C.

3.1.4 Groundwater Measurements

Groundwater level measurements were attempted in the open boreholes during dry-auger drilling. Measurements were taken initially during dry-auger drilling when groundwater was first encountered and at 5-min intervals thereafter over a 15-min time period. The groundwater measurements observed within the soil borings are described in Section 5.2 of this report.

3.2 Standpipe Piezometers and Slug Testing

Three (3) temporary standpipe piezometers (PZs) were installed within dry-augered boreholes adjacent to TB locations TB-2, TB-7 and TB-13 to depths of 40-ft, 35-ft and 50-ft below existing grade, respectively. The PZs were installed per the instructions provided by FNI as presented in Appendix D of this report.

The PZs included a 2-in diameter polyvinyl chloride (PVC) well screen section and riser casing. The piezometers also included a bottom cap, an air-vented top plug cap, one (1) 10-ft long section of screen pipe with 0.010-in slots and long sections of blank riser pipes at lengths specified by the Client. A grout backfill and 20/40 sand filter media were also installed according to the PZ specifications provided by the Client as shown in Appendix D of this report.

Water was bailed out of each PZ one (1) week after the piezometer installation with slug tests performed one (1) week after bailing of water. The slug tests, which provide field data to estimate the coefficient of hydraulic conductivity, K , were performed by rapidly displacing a “slug” while measuring the water level changes with a submersible pressure transducer and recording water levels with a data logger. Three (3) sets of falling (slug-in) and rising (slug-out) head tests were performed at each PZ location. Slug test reports presenting temperature, water level depth and pressure over time are provided in Appendix H. Raw slug testing data was also submitted to the Client under separate cover.

Approximately two (2) weeks after slug testing, our Geotechnician recorded initial groundwater readings of each PZ. We are also obtaining long-term readings on a monthly basis through June 2021 for a total of four (4) sets of PZ readings conducted for this scope of work. The PZs will be left in place and will be plugged by Others at a later date. Groundwater readings observed within the piezometers to-date are included in Section 5.2 of this report.

3.3 Field Electrical Resistivity Surveys

Resistivity soundings were performed at seven (7) locations as shown on the field program location plans provided in Appendix B. The surveys were performed in general accordance with the Standard Test Method for Field Measurement of Soil Resistivity using the Wenner Four-Electrode Method (ASTM G57) using a Stinger Electrical Resistivity Meter, stainless steel probes and low-impedance wire. The Wenner four-electrode method requires that four (4) metal electrodes be

placed with equal separation in a straight line in the surface of the soil to a depth not exceeding 5% of the minimum separation of the electrodes.

The center point of the surveys was conducted for a set of perpendicular resistivity lines as shown in the field program location plan provided in Appendix B. For each line, readings were taken using specific “a” spacing increments of 2.5-ft, 5-ft, 10-ft, 20-ft, 30-ft and 50-ft (when feasible).

The Stinger Electrical Resistivity Meter is a digital-memory earth electrical resistivity meter which measures self-potential differences of earth materials to controlled current flow by means of ionic conductance. The testing procedure involves a current being introduced into the earth obtained from Ohm’s Law by measuring the potential drop between two (2) electrodes that are positioned within the field of the current electrodes. For a given current flow, the potential drop across the surface will vary with and be proportional to the resistance of the material to current flow. The reports of electrical resistivity data are presented in Appendix F and results are discussed in Section 5.3.

4 LABORATORY SERVICES

4.1 General

Laboratory tests were assigned by FNI on selected soil samples to measure physical, engineering and analytical properties of the soil samples recovered from the test borings. The types and brief descriptions of the geotechnical and analytical laboratory tests performed are presented in Tables 4-1 and 4-2, respectively.

Table 4-1: Geotechnical Laboratory Testing Program	
Test Description	Test Method
Sieve Analysis with Hydrometer	ASTM D422
Amount of Material in Soils Finer than No. 200 Sieve	ASTM D1140
Water (Moisture) Content	ASTM D2216
Unconsolidated-Undrained Triaxial Compression	ASTM D2850
Liquid Limit, Plastic Limit and Plasticity Index	ASTM D4318
Thermal Conductivity	ASTM D5334
One-Dimensional Swell	ASTM D4546
Density (Unit Weight)	ASTM D7263
Soil Abrasivity Test	--

Table 4-2: Analytical Laboratory Testing Program	
Test Description	Test Method
Water-Soluble Sulfates	ASTM C1580
Water-Soluble Chlorides	ASTM D512
pH of Soil	ASTM G51

Standard geotechnical laboratory test results are presented on the test boring logs in Appendix C. Analytical test results are presented in Appendix E. The results of thermal conductivity, one-dimensional swell, sieve analyses and soil abrasivity are provided in the sections below and also presented in Appendix E.

4.2 Analytical Test Results

Samples were selected by FNI to perform analytical testing that included pH, water-soluble sulfates and water-soluble chlorides in soils per ASTM G51, ASTM C1580 and ASTM D512, respectively. The results are summarized in Table 4-3 on the following page and provided in Appendix E of the report.

Table 4-3: Summary of Analytical Laboratory Test Results					
Boring	Depth (ft)	Soil Type	pH	Sulfate Content (mg SO ₄ /kg)	Chloride Content (mg/kg)
TB-1	2.0 - 4.0	SC	8.34	500	120
TB-4	4.5 - 6.0	CH	6.16	500	90
TB-6	4.0 - 6.0	CH	9.75	900	240
TB-9	2.0 - 4.0	CH	4.42	600	270
TB-11	0.0 - 2.0	CH	7.16	3,300	150
TB-12	2.0 - 4.0	CH	5.66	600	60
	4.0 - 6.0	SC	8.69	500	60

4.3 Thermal Conductivity

Samples were selected by FNI to perform thermal conductivity tests in accordance with ASTM D5334. The results are summarized in Table 4-4 below with detailed reports provided in Appendix E.

Table 4-4: Summary of Thermal Conductivity Test Results			
Boring	Depth (ft)	Soil Type	Thermal Conductivity (W/m-K)
TB-1	6.0 - 8.0	SC	2.22
TB-5	4.0 - 6.0	CL	1.42
TB-8	2.0 - 4.0	CL	1.67
TB-13	4.0 - 6.0	CL	1.96

4.4 One-Dimensional Swell

Samples were selected by FNI to perform one-dimensional swell tests in accordance with ASTM D4546 - Test Method B. This test method measures the magnitude of one-dimensional wetting-induced swell or collapse deformation of intact soil specimens. The results are summarized in Table 4-5 below with detailed reports provided in Appendix E.

Table 4-5: Summary of One-Dimensional Swell Test Results			
Boring	Depth (ft)	Soil Type	% Swell
TB-1	2.0 - 4.0	SC	0.1
TB-2	4.0 - 6.0	SC	0.1
TB-6	4.0 - 6.0	CH	0.0
TB-9	2.0 - 4.0	CH	0.5
TB-11	6.0 - 8.0	CL	1.2

4.5 Sieve Analysis with Hydrometer

Samples were selected by FNI to perform sieve analysis with hydrometer tests in accordance with ASTM D422. This test method determines the distribution of particle sizes in soils retained on the No. 200 sieve. The results are summarized in Table 4-6 below with detailed test reports provided in Appendix E.

Table 4-6: Summary of Sieve Analysis Test Results									
Boring	Depth	Soil Type	% Gravel		% Sand			% Fines	
			Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
TB-1	12.0 - 14.0	SC	--	--	0.8	0.0	50.1	28.7	20.4
TB-3	6.0 - 8.0	CH	--	--	0.0	0.0	16.2	45.4	38.4
TB-6	8.0 - 10.0	SC	--	--	0.0	0.0	55.8	26.4	17.8
TB-9	4.0 - 6.0	CH	--	--	0.0	0.3	18.9	35.5	45.3
TB-11	16.0 - 18.0	CH	--	--	0.0	0.0	3.2	66.4	30.4
TB-12	2.0 - 4.0	CH	--	--	0.0	0.0	6.2	44.5	49.3

4.6 Soil Abrasivity

Samples were selected by FNI to perform soil abrasion testing. Table 4-7 provides the soil abrasivity test classification chart below. The results are summarized in Table 4-8 below with a detailed tests report provided in Appendix E.

Table 4-7: Soil Abrasivity Test Value Reference Classification Chart	
Category	Soil Abrasivity Test value (mg)
Low	≤ 7.0
Medium	7.1 - 21.9
High	≥ 22.0

Table 4-8: Summary of Soil Abrasivity Test Results				
Boring	Depth	Test No.		Average
		1	2	
TB-5	8.5-10	31.1	30.7	30.9
	10.5-12	43.1	42.1	42.6

5 PROJECT SITE CONDITIONS

Our interpretations of soil and groundwater conditions within the project alignment are based on information obtained at the location of the test borings performed for this project. This information has been used as the basis for our conclusions presented in this report. Subsurface conditions could vary at areas not explored by the project borings. Significant variations at areas within the project alignments not explored by the soil borings could require reassessment of our conclusions or supplemental investigations as deemed necessary by FNI.

5.1 Subsurface Soil Stratigraphy

The generalized subsurface profiles encountered within the project alignment were interpreted from the soil borings presented in Appendix C and the cross-sections in Appendix F.

The generalized subsurface profile encountered within the Lawson Pump Station site (TB-1 and TB-2) included 8-in of fill soils consisting of crushed aggregate underlain by loose sand (SC) to a depth of 20-ft below existing ground surface. Medium dense to very dense sand (SP/SP-SM) was encountered from 20-ft below existing ground surface to the boring completion depths of 40-ft.

The generalized subsurface profile encountered along the Tunnel Alignment (TB-3 to TB-10) consisted of intermittent and alternating layers of very soft to hard clay soils (CH/CL) and very loose to medium dense sand soils (SC/SP/SP-SM). A layer of organic clay soils (OH) was encountered within TB-4 from 18-ft to 24-ft below existing ground surface.

The generalized subsurface profile encountered within the Collier Raw Water Pump Station site (TB-11 to TB-13) consisted of stiff to hard clay soils (CH/CL) from existing grade to 8-ft underlain by medium dense sand (SC) to a depth of 14-ft below existing grade. Stiff to hard clay soils (CH/CL) were encountered from 14-ft to the boring completion depths of 50-ft.

Details of the soil conditions encountered in the test borings can be found on the corresponding logs of borings presented in Appendix C. Subsurface cross-sectional profiles for the pump station sites and tunnel alignment are provided in Appendix G of this report.

5.2 Groundwater Observations

Groundwater level measurements were attempted in the open boreholes when groundwater was first encountered during dry-auger drilling and at 5-min intervals over a 15-min time period. Groundwater measurements obtained from the test borings are summarized in Table 5-1 on the following page. Our PZ groundwater level readings to date are also summarized in Table 5-2 on the following page.

Table 5-1: Groundwater Level Measurements			
Test Boring	Free Water Depth During Dry-Auger Drilling (ft)	15-min Static Water Depth (ft)	15-min Total Borehole Depth (ft)
TB-1	20.0	13.5	--
TB-2	20.0	13.7	16.4
TB-3	4.0	0.67	2.5
TB-4	6.0	2.7	5.0
TB-5	10.0	3.2	6.0
TB-6	12.0	6.0	8.5
TB-7	10.0	4.6	6.8
TB-8	10.0	4.2	5.2
TB-9	NA ⁽¹⁾		
TB-10	10.0	5.0	6.0
TB-11	12.0	10.8	12.0
TB-12	12.0	10.0	11.5
TB-13	12.0	10.4	11.3

Notes: (1) Perched water at 2-ft below grade precluded free and static water level readings.

Table 5-2: Standpipe Piezometer Readings								
Piezometer No.	Installation Depth (ft)	Installation Date	Groundwater Depth below Existing Grade					
			2021 Reading Dates					
			3/15	3/24	4/26	6/8	6/30	7/21
PZ-2	40	02/12/2021	11.3-ft	--	11.2-ft	9.1-ft	10.5-ft	10.8
PZ-7	35	02/24/2021	--	2.8-ft	2.8-ft	0.7-ft	1.9-ft	5.0
PZ-13	50	02/23/2021	--	10.8-ft	11.2-ft	10.3-ft	10.8-ft	10.7

Groundwater levels at the project site could fluctuate with climatic and seasonal variations and should be verified before construction.

5.3 Apparent Soil Resistivity

The conversion of resistance, R, (ohms) to apparent resistivity is dependent upon the position and spacing of the potential electrodes (P₁ and P₂) relative to the current electrodes (C₁ and C₂). Apparent resistivity (ρ) is generally defined as $\rho = V$ (voltage) / I (current). The Wenner four-electrode method resistivity calculation uses the equation $\rho = 2\pi aR$ where “a” represents the equal electrode spacing essential to the Wenner array. C₁ to P₁ is equal to P₂ to P₂ which is equal to P₂ to C₂ for each spread. The “a” spacing can be measured in English units with the resulting resistivities expressed as ohm-ft or ohm-m. The “a” spacing determines the depths of investigation. Locations of ERSs are shown on the drawings included in Appendix B. The processed resistivity data from the ERSs are presented in Appendix F.

6 LIMITATIONS

6.1 Limitations

This final factual report has been prepared for the exclusive use of Freese and Nichols, Inc. and their project team for specific application to Collier Raw Water Pump Station and Tunnel in Beaumont, Texas. This report has been prepared in accordance with generally accepted geotechnical engineering practices common to the local area. No other warranty, expressed or implied, is made.

The information contained in this final geotechnical data report is based on data obtained from the subsurface explorations performed by TWE within the project alignment. TWE is not responsible for any claims, damages or liability associated with interpretation or reuse of the information contained in this factual report without expressed written authorization.

APPENDIX A

FNI REDACTED PROJECT EXHIBITS

PRELIMINARY GEOTECHNICAL INVESTIGATION PLAN

Collier RWPS and Tunnel

Prepared for:

City of Beaumont

December 1, 2020

Prepared by:

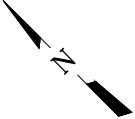
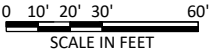
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- NOTES:
1. CONTRACTOR SHALL VERIFY LOCATION AND DEPTH OF ALL UTILITIES PRIOR TO BEGINNING OF DRILLING.



NO.	ISSUE	BY	DATE	F&N JOB NO. OFF:18999			
				DATE	10/01/18	DESIGNED	####
						DRAWN	####
						REVISED	####
						CHECKED	####
VERIFY SCALE				Bar is one inch on original drawing. If not one inch on this sheet, adjust scale.	FILE NAME		
					OVRA-SITE-BORE-LOCA (GRID)		
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City of Beaumont
Colliers Raw Water Pump Station

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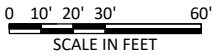
GEOTECHNICAL SITE PLAN

Freeze and Nichols, Inc.
Texas Registered Engineering Firm F-2144

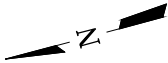
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1. CONTRACTOR SHALL VERIFY LOCATION AND DEPTH OF ALL UTILITIES PRIOR TO BEGINNING OF DRILLING.



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CIVIL

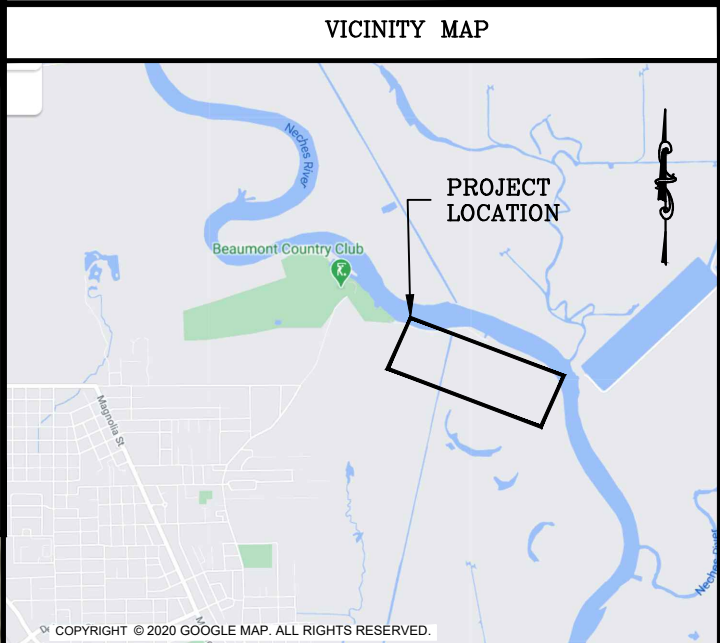
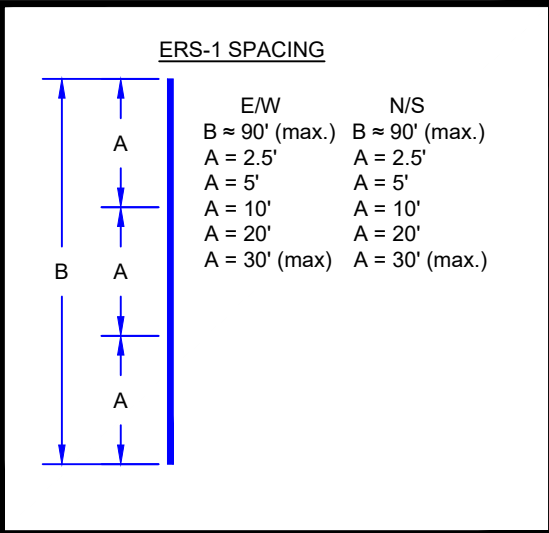
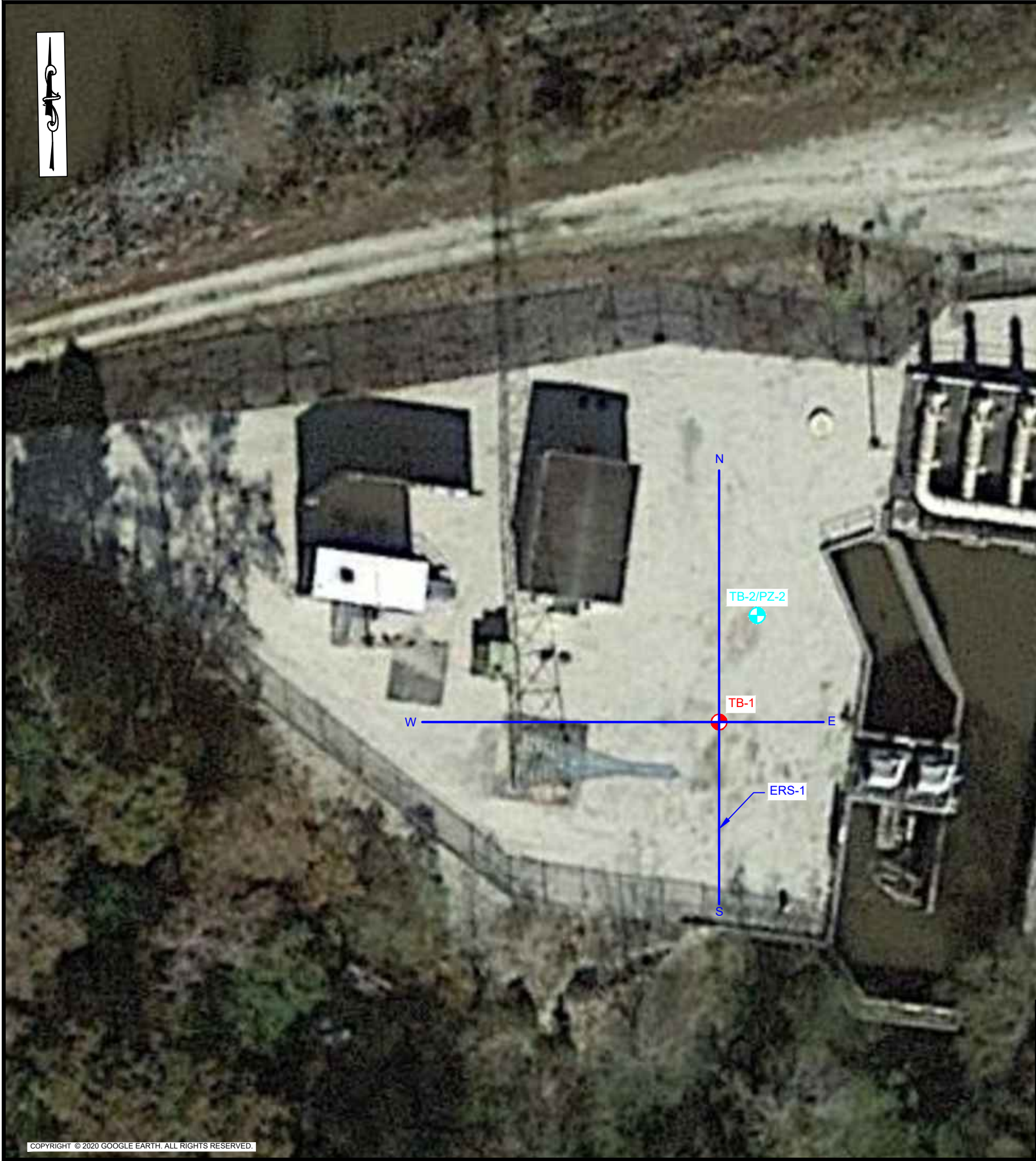
GEOTECHNICAL SITE PLAN




BORING TABLE			
BORING NO.	NORTHING	EASTING	POINT DESCRIPTION
TB-1	13990826.07	3520643.43	BORE
TB-2	13990849.78	3520651.35	PEIZOMETER
TB-3	13990832.65	3520293.41	BORE
TB-4	13990828.00	3519993.45	BORE
TB-5	13990823.36	3519693.48	BORE
TB-6	13990807.07	3519417.09	BORE
TB-7	13990829.07	3519416.75	PEIZOMETER
TB-8	13990953.46	3519128.48	BORE
TB-9	13991079.15	3518856.08	BORE
TB-10	13991204.84	3518583.68	BORE
TB-11	13991348.52	3518243.64	BORE
TB-12	13991370.13	3518237.40	PEIZOMETER
TB-13	13991347.23	3518221.18	BORE

[illegible]

APPENDIX B

FIELD PROGRAM LOCATION PLANS

[illegible]

LEGEND	
SYMBOL	DESCRIPTION
	TB LOCATION
	TB/PZ LOCATION
	ERS LOCATION

<i>Drawn</i>	<i>M.A.</i>	<i>03-16-2021</i>
<i>Checked</i>	<i>T.G.H.</i>	<i>03-16-2021</i>
<i>Approved</i>	<i>T.G.H.</i>	<i>03-16-2021</i>
<i>Scale</i>	<i>N.T.S.</i>	
<i>TWE DRAWING NO.</i> <u><i>21.23.014-1</i></u>		

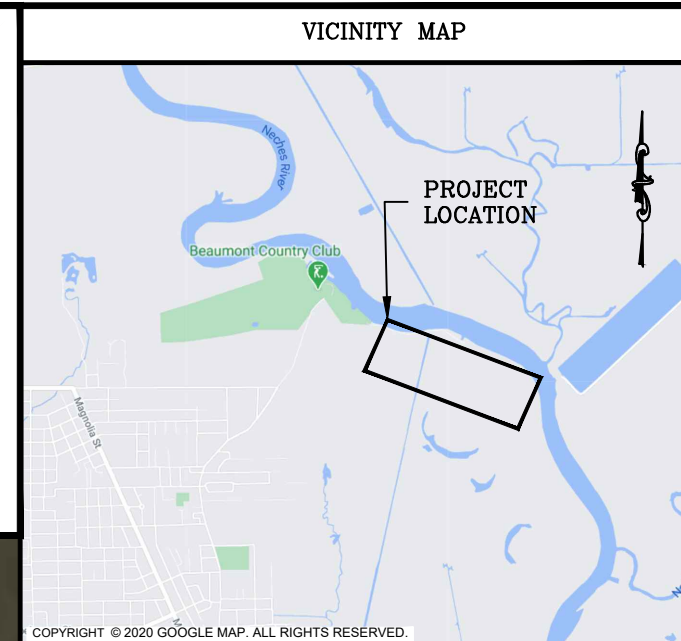
Tolunay-Wong  Engineers, Inc.




FIELD PROGRAM LOCATION PLAN
LAWSON PUMP STATION
COLLIER RAW WATER PUMP STATION AND TUNNEL
CITY OF BEAUMONT
BEAUMONT, TEXAS




ERS-3, 5, 7, 8, 10 SPACING

	E/W	N/S
B	$B \approx 150'$ (max.)	$B \approx 150'$ (max.)
A	$A = 2.5'$	$A = 2.5'$
A'	$A' = 5'$	$A' = 5'$
A	$A = 10'$	$A = 10'$
A	$A = 20'$	$A = 20'$
A	$A = 30'$	$A = 30'$
A	$A = 50'$ (max)	$A = 50'$ (max.)

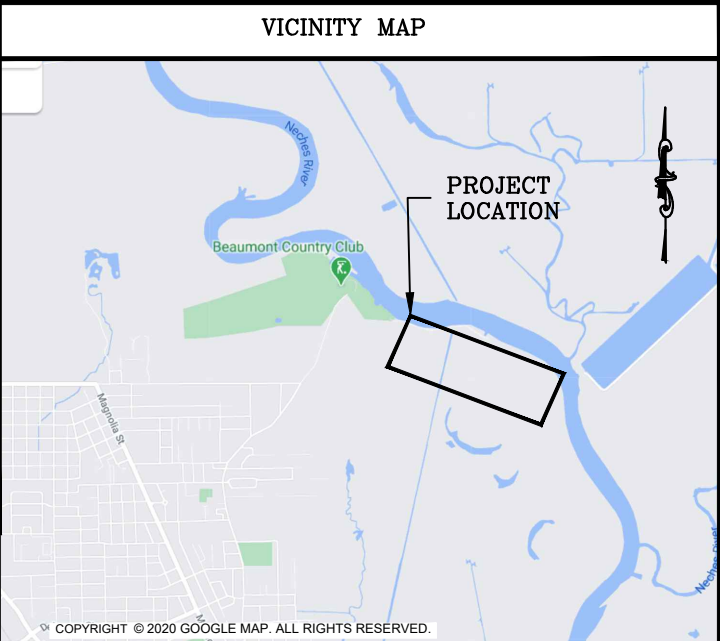
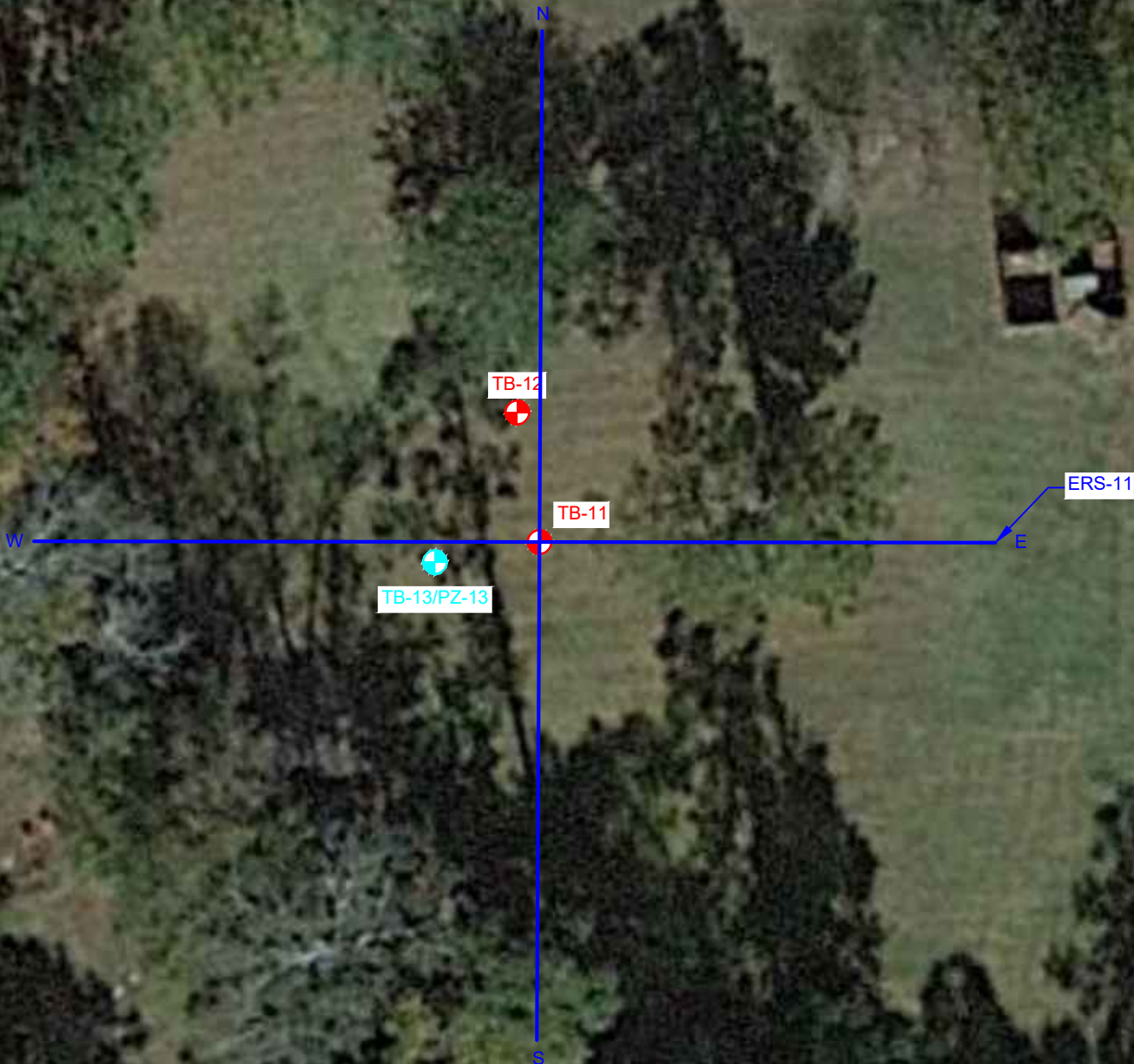
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LEGEND	
SYMBOL	DESCRIPTION
	TB LOCATION
	TB/PZ LOCATION
	ERS LOCATION

<i>Drawn</i>	<i>M.A.</i>	<i>03-16-2021</i>
<i>Checked</i>	<i>T.G.H.</i>	<i>03-16-2021</i>
<i>Approved</i>	<i>T.G.H.</i>	<i>03-16-2021</i>
<i>Scale</i>	<i>N.T.S.</i>	
TWE DRAWING NO. <u>21.23.014-2</u>		


Tolunay-Wong  Engineers, Inc.

**FIELD PROGRAM LOCATION PLAN
TUNNEL ALIGNMENT
COLLIER RAW WATER PUMP STATION AND TUNNEL
CITY OF BEAUMONT
BEAUMONT, TEXAS**



LEGEND	
SYMBOL	DESCRIPTION
	TB LOCATION
	TB/PZ LOCATION
	ERS LOCATION

<i>Drawn</i>	<i>M.A.</i>	<i>03-16-2021</i>
<i>Checked</i>	<i>T.G.H.</i>	<i>03-16-2021</i>
<i>Approved</i>	<i>T.G.H.</i>	<i>03-16-2021</i>
<i>Scale</i>	<i>N.T.S.</i>	
<i>TWE DRAWING NO.</i> <u><i>21.23.014-3</i></u>		

Tolunay-Wong  Engineers, Inc.

**FIELD PROGRAM LOCATION PLAN
COLLIER RAW WATER PUMP STATION
COLLIER RAW WATER PUMP STATION AND TUNNEL
CITY OF BEAUMONT
BEAUMONT, TEXAS**

APPENDIX C

GINT BORING LOGS AND KEY TO TERMS AND SYMBOLS

LOG OF BORING TB-1

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: 30.129417 deg 94.088722 deg	STATE PLANE COORD: N -- E --	SURFACE ELEVATION: +13 ft	DRILLING METHOD: Dry Aug.: 0' to 20' Wash Bored: 20' to 40'	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED
					MATERIAL DESCRIPTION														
	0				Fill: CRUSHED AGGREGATE (8")						16								
					Gray and tan CLAYEY SAND (SC)														
	10								(P)1.75		18								AN, SW
									(P)2.00		18	115	34	17	38				
	5				-gray and brown from 6' to 12'				(P)1.50		18	112					(C)1.12		TC
									(P)1.25		21								
	5								(T)0.55		20	110	36	23	48			(U)1.51	
	10				-gray with organics from 12' to 18'				(T)0.45		20				49				SA
	0								(P)1.50		18								
	15								(P)1.50		18	109	29	16	40			(U)1.33	
					-becomes gray and brown at 18'				(T)0.40		21								
	20				Medium dense, gray and brown POORLY GRADED SAND with SILT (SP-SM)					4/6" 4/6" 8/6"	27				6				
					-becomes gray with organics at 22.5'					5/6" 9/6" 15/6"	23								
	10									8/6" 11/6" 15/6"	23								
	25				Medium dense gray POORLY GRADED SAND (SP)					11/6" 13/6" 15/6"	26				3				
										9/6" 11/6" 13/6"	21								
	15									7/6" 10/6" 12/6"	21								
	30				Medium dense gray POORLY GRADED SAND with SILT (SP-SM)					6/6" 7/6" 9/6"	19				6				
					Bottom @ 40 ft.														

COMPLETION DEPTH: 40 ft
DATE BORING STARTED: 2-12-21
DATE BORING COMPLETED: 3-2-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014

NOTES: Free water = 20-ft. 15-min Static Water Depth = 13.5-ft. Total Hole Depth = N/A. Borehole backfilled with cement-bentonite grout. TC: Thermal Conductivity. AN: Analytical Testing. SW: Swell Test. SA: Sieve Analysis. U: Unconsolidated-Undrained. WOH: Weight of Hammer. C: Unconfined Compression. An unknown obstruction was encountered at 28-ft. TB-1 was offset, shotholed to 28-ft and completed. See report.



LOG OF BORING TB-2

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: 30.129500 deg 94.088694 deg STATE PLANE COORD: N -- E -- SURFACE ELEVATION: +13 ft DRILLING METHOD: Dry Aug.: 0' to 20' Wash Bored: 20' to 40'	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED
MATERIAL DESCRIPTION																
0	0				Fill: CRUSHED AGGREGATE (8")			16								
					Gray and brown CLAYEY SAND (SC)											
	10					(P)1.50		19								
	5					(P)1.75		17		31	15	38				SW
	5				-with organics from 6' to 8'	(P)1.50		19	107							
	5					(P)1.50		19		26	9	34				
	10					(P)1.50		22								
	0					(T)0.45		20								
	15					(P)1.50		22	107	31	13	46			(U)0.82	
	-5				-no recovery from 16.5' to 18' -loose from 16.5' to 20'		3/6" 7/8" 4/6"									
	20					2/6" 3/6" 3/6"		20				42				
						(T)0.40		25	101							
	-10				Medium dense gray POORLY GRADED SAND with SILT (SP-SM)		3/6" 7/8" 9/6"	24								
	25				-dense from 24.5' to 26.5'		12/6" 14/6" 26/6"	20				9				
	-15				-becomes very dense at 26.5'		20/6" 53/6" 27/3"	26								
	30						12/6" 32/6" 24/6"	22								
	-20				Very dense gray POORLY GRADED SAND (SP)		27/6" 63/6" --	18				4.5				
	35															
	-25				-becomes dense at 38.5'		22/6" 19/6" 19/6"	19								
	40				Bottom @ 40 ft.											

COMPLETION DEPTH: 40 ft
DATE BORING STARTED: 2-8-21
DATE BORING COMPLETED: 2-8-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014

NOTES: Free Water Depth = 20.0-ft. 15-min Static Water Depth = 13.7-ft. 15-min Total Hole Depth = 16.4-ft. Borehole was backfilled with cement-bentonite grout. SW: Swell Test. U: Unconsolidated-Undrained.



LOG OF BORING TB-3

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: 30.129500 deg 94.089833 deg STATE PLANE COORD: N -- E -- SURFACE ELEVATION: +5 ft DRILLING METHOD: Dry Aug.: 0' to 6' Wash Bored: 6' to 30'	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED
MATERIAL DESCRIPTION																
5	0			▽	Tan and gray CLAYEY SAND (SC)	(T)0.30		20								
					-becomes very loose at 2.5'		1/6" 2/6" 1/6"	28				47				
0	5				Very soft, gray, tan FAT CLAY with SAND (CH)	(T)0.25	WOH -	38								SA
					-becomes firm and gray with organics from 6' to 10'			51	76	71	43	84				
					-soft from 8' to 10'	(T)0.20		37	87						(C)0.24	
-5	10				Very loose gray CLAYEY SAND (SC)		WOH -	35				31				
							WOH -	38								
-10	15				Very loose gray POORLY GRADED SAND with SILT (SP-SM)		2/6" 2/6" 2/6"	27								
							1/6" 2/6" 1/6"	30				8				
					-becomes loose at 18.5'		3/6" 3/6" 4/6"									
-15	20						3/6" 3/6" 2/6"	24								
					Medium dense gray POORLY GRADED SAND (SP)		6/6" 7/6" 9/6"	24				3				
-20	25						6/6" 7/6" 8/6"									
							6/6" 8/6" 11/6"	23								
-25	30						7/6" 8/6" 8/6"	20				3				
					Bottom @ 30 ft.											
-30	35															
-35	40															

COMPLETION DEPTH: 30 ft
DATE BORING STARTED: 2-25-21
DATE BORING COMPLETED: 2-25-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014

NOTES: Free Water Depth = 4.0-ft. 15-min Static Water Depth = 0.67-ft. 15-min Total Hole Depth = 2.5-ft. Borehole was backfilled with cement-bentonite grout. SA: Sieve Analysis. C: Unconfined Compression. WOH: Weight of Hammer.

LOG OF BORING 21.23.014.GPJ TWEI HOUSTON.GDT 4/7/21



LOG OF BORING TB-4

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE	SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: STATE PLANE COORD: SURFACE ELEVATION: DRILLING METHOD: Dry Aug.: 0' to 10' Wash Bored: 10' to 30'	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED
						MATERIAL DESCRIPTION											
0	0				100	Medium dense tan POORLY GRADED SAND with SILT (SP-SM)		5/6" 5/6" 6/6"	16								
5	5					-becomes loose at 2.5'	3/6" 4/6" 5/6"	15		12							
5	5				100	Soft, tan and gray FAT CLAY with SAND (CH)	(P)1.75	1/6" 2/6" 1/6"	28	98	59	43	78			(C)1.59	AN
0	0					-becomes stiff at 6'	28										
10	10				100	Tan and gray CLAYEY SAND (SC)		WOH -	29		39	20					
-5	-5					-becomes very loose, gray and brown at 10.5'											
15	15				100	Medium dense gray POORLY GRADED SAND with SILT (SP-SM)		- 6/6" 6/6"	47								
-10	-10					-becomes very loose at 14.5'	3/6" 2/6" 2/6"	24		8							
					100			1/6" -	43								
20	20					Firm gray ORGANIC CLAY (OH)	(T)0.25		111	44						(U)0.54	
-15	-15				100	-with shell fragments from 18' to 22'	(T)0.25		109	44	152	108	92				
							(T)0.25		104								
25	25				100	Medium dense gray POORLY GRADED SAND with SILT (SP-SM)		5/6" 10/6" 11/6"	23								
-20	-20						5/6" 7/6" 10/6"	23		9							
30	30				100	-becomes loose at 28.5'		5/6" 3/6" 3/6"	16								
-25	-25																
35	35				100	Bottom @ 30 ft.											
-30	-30																
40	40				100												

COMPLETION DEPTH: 30 ft
DATE BORING STARTED: 2-25-21
DATE BORING COMPLETED: 2-25-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014

NOTES: Free Water Depth = 6.0-ft. 15-min Static Water Depth = 2.7-ft. 15-min Total Hole Depth = 5.0-ft. Borehole was backfilled with cement-bentonite grout. AN: Analytical Testing. U: Unconsolidated-Undrained. C: Unconfined Compression. WOH: Weight of Hammer.



LOG OF BORING TB-5

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE	SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: STATE PLANE COORD: SURFACE ELEVATION: DRILLING METHOD: Dry Aug.: 0' to 10' Wash Bored: 10' to 30'	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED	
MATERIAL DESCRIPTION																		
5	0				▽	Stiff, gray and tan SANDY LEAN CLAY (CL)	(P)1.50		21									
						(P)1.75		28	40	21	64							
0	5					(P)1.75		22	101						(C)0.90	TC		
						Tan and gray CLAYEY SAND (SC)	(P)1.50		23	103	32	13	40			(U)0.72		
-5	10					Loose, gray and tan POORLY GRADED SAND (SP) -becomes gray at 10.5' -very loose from 10.5' to 12' -medium dense from 14.5' to 20'		3/6" 5/6" 5/6"	24									
							1/6" 1/6" 2/6"	23										
		2/6" 3/6" 2/6"	23															
-10	15	5/6" 6/6" 7/6"	24				3											
		2/6" 4/6" 8/6"	24															
		4/6" 6/6" 8/6"	23															
-15	20	3/6" 4/6" 4/6"	25				2											
		4/6" 3/6" 2/6"	25															
-20	25						Very loose gray SILTY SAND (SM) -with clay seams from 24.5' to 26' -medium dense from 26.5' to 28' -becomes loose at 28.5'		2/6" 2/6" 2/6"	57								
							2/6" 6/6" 9/6"	24			13							
-25	30					3/6" 3/6" 4/6"	22											
						Bottom @ 30 ft.												
-30	35																	
-35	40																	

COMPLETION DEPTH: 30 ft
DATE BORING STARTED: 2-10-21
DATE BORING COMPLETED: 2-10-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014






NOTES: Free Water Depth = 10.0-ft. 15-min Static Water Depth = 3.2-ft. 15-min Total Hole Depth = 6.0-ft. Borehole was backfilled with cement-bentonite grout. TC: Thermal Conductivity. U: Unconsolidated-Undrained. C: Unconfined Compression.



LOG OF BORING TB-6

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE	SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: 30.129528 deg STATE PLANE COORD: N -- E -- SURFACE ELEVATION: +5 ft DRILLING METHOD: Dry Aug.: 0 ' to 12 ' Wash Bored: 12 ' to 35 '	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED
MATERIAL DESCRIPTION																	
5	0					Firm, gray and tan FAT CLAY (CH)	(T)0.30		27								
						-becomes stiff at 2'	(P)1.50		30		57	35	88				
0	5						(P)1.50		32								AN, SW
						Gray CLAYEY SAND (SC)	(T)0.35		35								
							(T)0.15		44	84	68	45	44				SA
-5	10						(T)0.10		38	76						(U)0.22	
						-becomes loose at 12.5'		1/6" 2/6" 4/6"	45				24				
-10	15					-becomes medium dense at 14.5'		2/6" 5/6" 8/6" 3/6" 5/6" 6/6"	25 25								
-15	20					Firm gray SANDY FAT CLAY (CH)		1/6" 2/6" 4/6"	54				57				
						Medium dense gray POORLY GRADED SAND (SP)		5/6" 6/6" 5/6" 5/6" 7/6" 9/6" 3/6" 5/6" 9/6" 7/6" 9/6" 11/6" 5/6" 9/6" 11/6"	23 24 24 24 25				4				
-20	25																
-25	30																
-30	35					Medium dense gray POORLY GRADED SAND with SILT (SP-SM)		5/6" 5/6" 7/6"	21				7				
						Bottom @ 35 ft.											
-35	40																

COMPLETION DEPTH: 35 ft
DATE BORING STARTED: 2-9-21
DATE BORING COMPLETED: 2-9-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014

NOTES: Free Water Depth = 12.0-ft. 15-min Static Water Depth = 6.0-ft. 15-min Total Hole Depth = 8.5-ft. Borehole was backfilled with cement-bentonite grout. AN: Analytical Testing. SW: Swell Test. SA: Sieve Analysis. U: Unconsolidated-Undrained. TC: Thermal Conductivity.



LOG OF BORING TB-7

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: STATE PLANE COORD: SURFACE ELEVATION: DRILLING METHOD: Dry Aug.: 0' to 10' Wash Bored: 10' to 35'	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED
MATERIAL DESCRIPTION																
0	0				Stiff, gray and tan SANDY LEAN CLAY (CL)	(P)1.50		27		45	25	67				
						(P)1.75		30								
	0			▽	-becomes firm at 4'	(T)0.30		22	107						(C)0.92	
	5															
					Gray CLAYEY SAND (SC)	(T)0.25		25	104	29	7	27				
	-5				-becomes very loose at 8.5'		WOH -	42								
	10						1/6" 2/6" 2/6"	31								
					Firm gray SANDY FAT CLAY (CH)		1/6" 2/6" 3/6"	51				62				
	-10															
	15				Loose gray POORLY GRADED SAND (SP)		2/6" 3/6" 5/6"	23								
							2/6" 3/6" 6/6"	23								
	-15				-medium dense from 18.5' to 20'		3/6" 8/6" 8/6"									
	20						3/6" 3/6" 3/6"	25				4				
							2/6" 4/6" 6/6"	20								
	-20				-becomes medium dense at 24.5'		6/6" 10/6" 12/6"									
	25						6/6" 9/6" 14/6"	32								
					Medium dense gray POORLY GRADED SAND with SILT (SP-SM)		3/6" 9/6" 15/6"	23				5				
	-25															
	30				-becomes loose at 33.5'		5/6" 4/6" 4/6"	22								
	-30															
	35				Bottom @ 35 ft.											
	-35															
	40															

COMPLETION DEPTH: 35 ft
DATE BORING STARTED: 2-9-21
DATE BORING COMPLETED: 2-9-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014

NOTES: Free Water Depth = 10.0-ft. 15-min Static Water Depth = 4.6-ft. 15-min Total Hole Depth = 6.8-ft. Borehole was backfilled with cement-bentonite grout. C: Unconfined Compression. WOH: Weight of Hammer.

LOG OF BORING 21.23.014.GPJ TWEI HOUSTON.GDT 4/7/21



LOG OF BORING TB-8

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: 30.129944 deg 94.093500 deg STATE PLANE COORD: N -- E -- SURFACE ELEVATION: +6 ft DRILLING METHOD: Dry Aug.: 0' to 10' Wash Bored: 10' to 30'	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED
MATERIAL DESCRIPTION																
0	5				Tan and brown POORLY GRADED SAND (SP), with roots and organics			21								
5	10				Stiff, tan and gray SANDY LEAN CLAY (CL) -becomes firm at 4'	(P)1.75 (T)0.30		16 26	109 99						(C)0.45 (U)0.61	TC
10	15				Firm, gray and tan FAT CLAY (CH) -with organics from 6' to 8'	(T)0.40 (T)0.35		38 55								
15	20				-becomes very soft and gray with sand pockets at 10.5'		WOH - WOH -	68 72		87	57	88				
20	25				Loose gray POORLY GRADED SAND with SILT (SP-SM)		3/6" 3/6" 6/6" 1/6" 4/6" 6/6"	22 22				10				
25	30				Medium dense gray POORLY GRADED SAND (SP)		4/6" 4/6" 7/6" 9/6" 9/6" 10/6" 5/6" 6/6" 7/6" 8/6" 9/6" 10/6" 3/6" 7/6" 10/6" 7/6" 9/6" 13/6"	24 21 22 24 24 24				0 2 3				
30	35				Bottom @ 30 ft.											
35	40															

COMPLETION DEPTH: 30 ft
DATE BORING STARTED: 2-10-21
DATE BORING COMPLETED: 2-10-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014

NOTES: Free Water Depth = 10.0-ft. 15-min Static Water Depth = 4.2-ft. 15-min Total Hole Depth = 5.2-ft. Borehole was backfilled with cement-bentonite grout. TC: Thermal Conductivity. U: Unconsolidated-Undrained. C: Unconfined Compression. WOH: Weight of Hammer.

LOG OF BORING 21.23.014.GPJ TWEI HOUSTON.GDT 4/7/21



LOG OF BORING TB-9

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE	SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: 30.130333 deg STATE PLANE COORD: N -- E -- SURFACE ELEVATION: +5 ft DRILLING METHOD: Dry Aug.: 0' to 12' Wash Bored: 12' to 30'	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED	
MATERIAL DESCRIPTION																		
5	0				▽	Firm, gray and tan SANDY LEAN CLAY (CL)	(T)0.35		24		39	23	50					
				Stiff, gray and tan FAT CLAY with SAND (CH)	(P)2.00	25												
					(P)2.00	26	98	59	40	80								
0	5				(P)2.25	26												
					(P)1.50	29												
						Stiff, gray and brown SANDY FAT CLAY (CH)	(P)2.00		26	96	53	37	63					
					(P)2.00	29												
					(P)1.50	31												
-5	10					Loose gray POORLY GRADED SAND with SILT (SP-SM)		4/6" 3/6" 4/6"	25				8					
						-becomes medium dense at 18.5'		5/6" 7/6" 13/6"	22									
						Medium dense gray POORLY GRADED SAND (SP)		6/6" 8/6" 11/6"	21									
								5/6" 7/6" 9/6"	21				4					
-20	25							5/6" 8/6" 10/6"	21									
						Medium dense gray POORLY GRADED SAND with SILT (SP-SM)		4/6" 3/6" 9/6"	27									
								11/6" 11/6" 12/6"	18				5					
-25	30					Bottom @ 30 ft.												
-30	35																	
-35	40																	

COMPLETION DEPTH: 30 ft
DATE BORING STARTED: 2-25-21
DATE BORING COMPLETED: 2-25-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014

NOTES: Perched water at 2-ft below grade precluded free and state water level readings. Borehole was backfilled with cement-bentonite grout. AN: Analytical Testing. SW: Swell Test. SA: Sieve Analysis.

LOG OF BORING 21.23.014.GPJ TWEI HOUSTON GDT 4/7/21



LOG OF BORING TB-10

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: 30.130722 deg 94.095167 deg STATE PLANE COORD: N -- E -- SURFACE ELEVATION: +6 ft DRILLING METHOD: Dry Aug.: 0' to 10' Wash Bored: 10' to 30'	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED
					MATERIAL DESCRIPTION											
0	5				FILL: CRUSHED AGGREGATE (24")			12								
	5				Soft, gray and tan SANDY FAT CLAY (CH)		2/6" 1/6" 2/6"	19								
	5				-becomes stiff at 4'	(P)1.50		25	94	54	34	69				
0					Tan CLAYEY SAND (SC)	(T)0.20		23								
	10				Loose gray POORLY GRADED SAND with SILT (SP-SM)		3/6" 3/6" 3/6"	24				11				
	-5				-medium dense from 10.5' to 14'		7/6" 5/6" 8/6"	25								
	15						4/6" 5/6" 6/6"	24								
	-10				-becomes medium dense at 16.5'		3/6" 3/6" 5/6"	22				7				
	20						5/6" 9/6" 10/6"	25								
	-15				Medium dense gray POORLY GRADED SAND (SP)		2/6" 7/6" 10/6"	23				3				
	25				-with organics from 24.5' to 28'		7/6" 10/6" 15/6"									
	-20				-with gravel from 26.5' to 28'		9/6" 6/6" 5/6"	24								
	30				Hard, gray and tan LEAN CLAY with SAND (CL)	(P)4.50	5/6" 4/6" 5/6"	31								
	-25				Bottom @ 30 ft.			19		46	32	71				
	35															
	-30															
	40															

COMPLETION DEPTH: 30 ft
DATE BORING STARTED: 2-26-21
DATE BORING COMPLETED: 2-26-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014

NOTES: Free Water Depth = 10.0-ft. 15-min Static Water Depth = 5.0-ft. 15-min Total Hole Depth = 6.0-ft. Borehole was backfilled with cement-bentonite grout.



LOG OF BORING TB-11

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: 30.131139 deg 94.09625 deg STATE PLANE COORD: N -- E -- SURFACE ELEVATION: +20 ft DRILLING METHOD: Dry Aug.: 0' to 16' Wash Bored: 16' to 50'	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED
MATERIAL DESCRIPTION																
20	0				Stiff, gray and tan FAT CLAY (CH)	(P)1.50		33		94	74	91				AN
						(P)2.00		26								
15	5				Hard, gray and tan SANDY LEAN CLAY (CL)	(P)4.50		19	111							
					-very stiff from 6' to 8'	(P)4.00		18	111	44	31	59			(C)2.96	SW
					-become stiff at 8'	(P)2.50		18								
10	10				Medium dense tan CLAYEY SAND (SC)		4/6" 7/6" 10/6"	21								
					-with calcareous nodules from 12.5' to 14'		7/6" 7/6" 7/6"	25				33				
5	15						5/6" 7/6" 9/6"	30								
					Very stiff, gray and tan FAT CLAY (CH)	(P)3.00		26	105	62	39	97			(U)1.82	SA
						(P)3.75		30								
0	20				-with ferrous nodules from 20' to 22'	(P)1.75		32								
					-stiff from 20' to 24'											
					-slickensided from 22' to 26'	(P)2.25		22	109	52	38	93			(U)1.80	
						(P)3.50		20								
-5	25					(P)3.00		22								
					-with sand pockets from 28' to 35'	(P)4.25		24		72	53	96				
-10	30					(P)4.25										
-15	35				-slickensided from 38' to 40'	(P)3.50		23								
-20	40															

COMPLETION DEPTH: 50 ft
DATE BORING STARTED: 2-26-21
DATE BORING COMPLETED: 2-26-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014

NOTES: Free Water Depth = 12.0-ft. 15-min Static Water Depth = 10.8-ft. 15-min Total Hole Depth = 12.0-ft. Borehole was backfilled with cement-bentonite grout. AN: Analytical Testing. SW: Swell Test. SA: Sieve Analysis. U: Unconsolidated-Undrained. C: Unconfined Compression.



LOG OF BORING TB-11

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE	SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: 30.131139 deg 94.09625 deg STATE PLANE COORD: N -- E -- SURFACE ELEVATION: +20 ft DRILLING METHOD: Dry Aug.: 0 ' to 16 ' Wash Bored: 16 ' to 50 '	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED
-20	40																
-25	45					Stiff, gray and tan LEAN CLAY (CL), with sand pockets and sand seams	(P)2.50		20		31	18	89				
-30	50					-becomes very stiff at 48'	(P)4.25		20								
-35	55					Bottom @ 50 ft.											
-40	60																
-45	65																
-50	70																
-55	75																
-60	80																

COMPLETION DEPTH: 50 ft
DATE BORING STARTED: 2-26-21
DATE BORING COMPLETED: 2-26-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014

NOTES: Free Water Depth = 12.0-ft. 15-min Static Water Depth = 10.8-ft. 15-min Total Hole Depth = 12.0-ft. Borehole was backfilled with cement-bentonite grout. AN: Analytical Testing. SW: Swell Test. SA: Sieve Analysis. U: Unconsolidated-Undrained. C: Unconfined Compression.

LOG OF BORING 21.23.014.GPJ TWEI HOUSTON GDT 4/7/21



LOG OF BORING TB-12

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: 30.131194 deg STATE PLANE COORD: N -- E -- SURFACE ELEVATION: +20 ft DRILLING METHOD: Dry Aug.: 0' to 12' Wash Bored: 12' to 50'	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED
MATERIAL DESCRIPTION																
20	0				Stiff, gray and tan FAT CLAY (CH)	(T)0.75 (P)2.50		24								
					-becomes very stiff at 2'	(P)3.00		20		74	57	94				AN, SA
15	5				Gray and tan CLAYEY SAND (SC) -with ferrous nodules from 4' to 8'	(P)4.50 (P)4.50 (T)0.30		17 16 19							(C)2.34	AN
10	10			▽	-becomes medium dense at 10.5'		9/6" 9/6" 8/6" 5/6" 6/6" 7/6"	19 24				32				
5	15				Stiff, tan and gray FAT CLAY with SAND (CH)		4/6" 6/6" 7/6" 3/6" 5/6" 4/6"	32 29		54	33	76				
0	20				Very stiff, brown and gray FAT CLAY (CH) -slickensided from 18' to 20'	(P)3.25 (P)3.00		31 35	91						(U)2.13	
					-stiff with slickensides from 22' to 24'	(P)2.50 (P)3.25		21 20	107	55	40	96				
-5	25					(P)3.25 (P)4.00		22 24	105						(U)2.41	
-10	30					(P)3.75		22								
-15	35															
-20	40				-slickensided from 38' to 40'	(P)3.50		28								

COMPLETION DEPTH: 50 ft
DATE BORING STARTED: 2-23-21
DATE BORING COMPLETED: 2-23-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014

NOTES: Free Water Depth = 12.0-ft. 15-min Static Water Depth = 10.0-ft. 15-min Total Hole Depth = 11.5-ft. Borehole was backfilled with cement-bentonite grout. AN: Analytical Testing. SA: Sieve Analysis. U: Unconsolidated-Undrained. C: Unconfined Compression.

LOG OF BORING TB-12

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE	SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: 30.131194 deg 94.09625 deg STATE PLANE COORD: N -- E -- SURFACE ELEVATION: +20 ft DRILLING METHOD: Dry Aug.: 0 ' to 12 ' Wash Bored: 12 ' to 50 '	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED
-20	40					MATERIAL DESCRIPTION											
-25	45					Very stiff, gray and brown LEAN CLAY (CL), with sand pockets	(P)3.25		18		33	20	87				
-30	50					Hard, gray and tan FAT CLAY with SAND (CH)	(P)4.50		20								
-35	55					Bottom @ 50 ft.											
-40	60																
-45	65																
-50	70																
-55	75																
-60	80																

COMPLETION DEPTH: 50 ft
DATE BORING STARTED: 2-23-21
DATE BORING COMPLETED: 2-23-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014

NOTES: Free Water Depth = 12.0-ft. 15-min Static Water Depth = 10.0-ft. 15-min Total Hole Depth = 11.5-ft. Borehole was backfilled with cement-bentonite grout. AN: Analytical Testing. SA: Sieve Analysis. U: Unconsolidated-Undrained. C: Unconfined Compression.

LOG OF BORING 21.23.014.GPJ TWEI HOUSTON GDT 4/7/21



LOG OF BORING TB-13

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: 30.131139 deg 94.096306 deg STATE PLANE COORD: N -- E -- SURFACE ELEVATION: +20 ft DRILLING METHOD: Dry Aug.: 0' to 12' Wash Bored: 12' to 50'	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED
MATERIAL DESCRIPTION																
20	0				Stiff, gray and tan FAT CLAY (CH)	(P)2.00										
						(P)2.50		26		81	61	92				
15	5				Very stiff, gray and tan LEAN CLAY (CL)	(P)3.00		17	111						(C)1.94	TC
					Hard, gray and tan SANDY LEAN CLAY (CL)	(P)4.50		17	114	41	25	51				
10	10			▽	Medium dense, tan and gray CLAYEY SAND (SC)		5/6" 7/6" 9/6"	20								
							6/6" 6/6" 6/6"	23				50				
							8/6" 8/6" 7/6"	26								
5	15				Stiff, tan and gray LEAN CLAY with SAND (CL)		5/6" 7/6" 8/6"	33				81				
					Stiff, gray and tan FAT CLAY (CH)		3/6" 4/6" 5/6"	29								
0	20				-very stiff from 18' to 20'	(P)3.00		28	96							
					-with calcareous nodules from 20' to 22'	(P)2.50		32	92	73	49	94			(C)1.78	
						(P)2.50		16	114							
						(P)2.25		20								
-5	25					(P)2.50		22		54	39	96				
					-becomes very stiff at 28'	(P)3.50		23	103						(C)2.40	
					-with sand pockets from 28' to 30'											
-10	30					(P)3.50		22								
-15	35															
					-slickensided from 38' to 40'	(P)3.50		34	93							
-20	40															

COMPLETION DEPTH: 50 ft
DATE BORING STARTED: 2-8-21
DATE BORING COMPLETED: 2-8-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014

NOTES: Free Water Depth = 12.0-ft. 15-min Static Water Depth = 10.4-ft. 15-min Total Hole Depth = 11.3-ft. Borehole was backfilled with cement-bentonite grout. U: Unconsolidated-Undrained. C: Unconfined Compression.

LOG OF BORING 21.23.014.GPJ TWEI HOUSTON.GDT 4/7/21



LOG OF BORING TB-13

PROJECT: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

CLIENT: Freese and Nichols, Inc.
Pearland, Texas

ELEVATION (FT)	DEPTH (FT)	SAMPLE TYPE	SYMBOL	SAMPLE NUMBER	SAMPLE RECOVERY (FIELD %/LAB %)	GPS COORDINATE: 30.131139 deg 94.096306 deg	STATE PLANE COORD: N -- E --	SURFACE ELEVATION: +20 ft	DRILLING METHOD: Dry Aug.: 0' to 12' Wash Bored: 12' to 50'	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING #200 SIEVE (%)	ORGANIC CONTENT (%)	SHEAR STRENGTH FIELD TEST, Su (ksf)	SHEAR STRENGTH LAB TEST, Su (ksf)	OTHER TESTS PERFORMED
-20	40					MATERIAL DESCRIPTION														
-25	45					-becomes hard with sand pockets from 43' to 50'				(P)4.50		18		21	7	86				
-30	50					Bottom @ 50 ft.				(P)4.50		22								
-35	55																			
-40	60																			
-45	65																			
-50	70																			
-55	75																			
-60	80																			

COMPLETION DEPTH: 50 ft
DATE BORING STARTED: 2-8-21
DATE BORING COMPLETED: 2-8-21
LOGGER: C. Watts
PROJECT NO.: 21.23.014

NOTES: Free Water Depth = 12.0-ft. 15-min Static Water Depth = 10.4-ft. 15-min Total Hole Depth = 11.3-ft. Borehole was backfilled with cement-bentonite grout. U: Unconsolidated-Undrained. C: Unconfined Compression.



KEY TO SYMBOLS AND TERMS USED ON BORING LOGS FOR SOIL

Most Common Unified Soil Classifications System Symbols

	Lean Clay (CL)		Well Graded Sand (SW)
	Lean Clay w/ Sand (CL)		Well Graded Sand w/ Gravel (SW-GM)
	Sandy Lean Clay (CL)		Poorly Graded Sand (SP)
	Fat Clay (CH)		Poorly Graded Sand w/ Silt (SP-SM)
	Fat Clay w/ Sand (CH)		Silt (ML)
	Sandy Fat Clay (CH)		Elastic Silt (MH)
	Silty Clay (CL-ML)		Elastic Silt w/ Sand (MH-SP)
	Sandy Silty Clay (CL-ML)		Silty Gravel (GM)
	Silty Clayey Sand (SC-SM)		Clayey Gravel (GC)
	Clayey Sand (SC)		Well Graded Gravel (GW)
	Sandy Silt (ML)		Well Graded Gravel w/ Sand (SP-GM)
	Silty Sand (SM)		Poorly Graded Gravel (GP)
	Silt w/ Sand (ML)		Peat

Miscellaneous Materials

	Fill		Concrete		Asphalt and/or Base
--	------	--	----------	--	---------------------

Sampler Symbols

Meaning

	Pavement core
	Thin - walled tube sample
	Standard Penetration Test (SPT)
	Auger sample
	Sampling attempt with no recovery

Field Test Data

16/24"	Sample Recovery (%)
(P) 2.50	Pocket penetrometer reading in tons per square foot
(T) 1.13	Torvane Measurement in tons per square foot
8/6"	Blow count per 6 - in. interval of the Standard Penetration Test
DP	Drill rig down pressure during tube push in pounds/square inch
PID	Photoionization detector
PPM	Parts per million
	Observed free water during drilling
	Observed static water level

Laboratory Test Data

Wc (%)	Moisture content in percent
Dens. (pcf)	Dry unit weight in pounds per cubic foot
LL	Liquid Limit in percent
PI	Plasticity Index
#200 (%)	Percent passing the No. 200 mesh sieve

Strength Legend (ksf)

Qu	Unconfined Compressive Strength
Su	Undrained Shear Strength
UU	Unconsolidated-Undrained Test
UC	Unconfined Compression Test
T	Torvane
P	Pocket Penetrometer ***
M	Miniature Vane Shear

RELATIVE DENSITY OF COHESIONLESS & SEMI-COHESIONLESS SOILS

The following descriptive terms for relative density apply to cohesionless soils such as gravels, silty sands, and sands as well as semi-cohesive and semi-cohesionless soils such as sandy silts, and clayey sands.

Relative Density	Typical N Value Range*
Very Loose	Less than 4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	Greater than 50

* N is the number of blows from a 140-lb weight having a free fall of 30-in. required to penetrate the final 12-in. of an 18-in. sample interval.

CONSISTENCY OF COHESIVE SOILS

The following descriptive terms for consistency apply to cohesive soils such as clays, sandy clays, and silty clays.

Undrained Shear Strength, Su (ksf)**	Consistency	Blows per Foot
< 0.25	Very soft	< 2
0.25 - 0.50	Soft	2-4
0.50 - 1.00	Medium	4-8
1.00 - 2.00	Firm	8-15
2.00 - 4.00	Very Firm	15-30
> 4.00	Hard	> 30

** Su = T = M; Su = Qu/2 = P/2

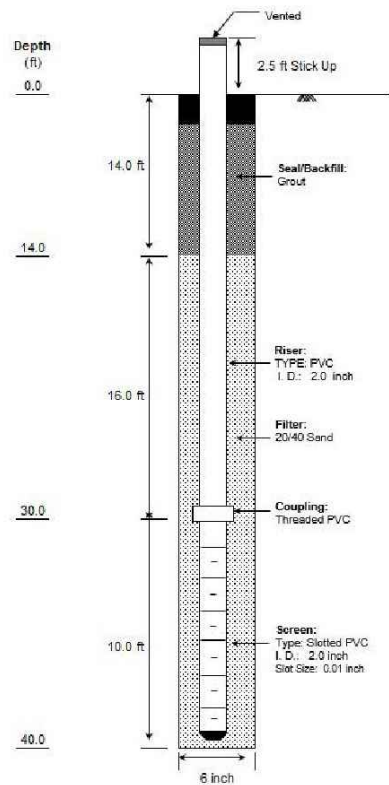
*** Based on our experience, we adjusted the field measurements of the undrained shear strength of natural, overconsolidated Pleistocene Gulf Coast clays by applying a correction factor of 0.67 to the penetrometer readings. The strengths measured by penetrometer are partially controlled by the presence of macroscopic soil defects and features such as slickensides, which are generally not reflected in penetrometer readings.



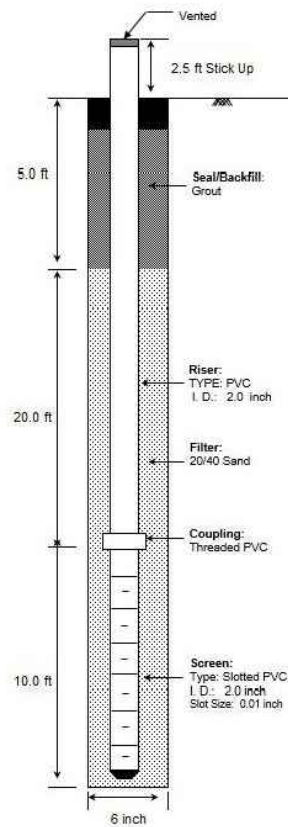
APPENDIX D

FNI STANDPIPE PIEZOMETER INSTALLATIONS

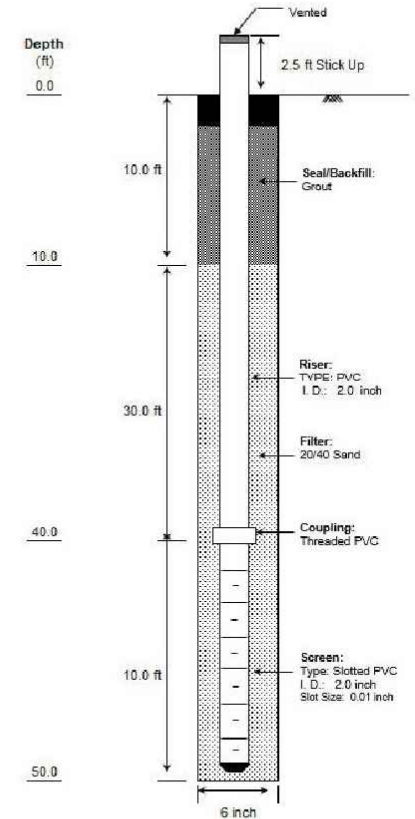
PZ-2 (TB-2)



PZ-7 (TB-7)



PZ-13 (TB-13)



Tolunay-Wong  **Engineers, Inc.**

PIEZOMETER INSTALLATION CROSS SECTION
COLLIER RAW WATER PUMP STATION AND TUNNEL
CITY OF BEAUMONT
BEAUMONT, TEXAS

<i>Drawn</i>	<i>M.A.</i>	<i>07-22-2021</i>
<i>Checked</i>	<i>T.G.H.</i>	<i>07-22-2021</i>
<i>Approved</i>	<i>T.G.H.</i>	<i>07-22-2021</i>
<i>Scale</i>	<i>N.T.S.</i>	
<i>TWE DRAWING NO.</i>		<i>21.23.014-4</i>

APPENDIX E

TEST REPORTS

ANALYTICAL LABORATORY TEST RESULTS

Soil pH Test (ASTM G51)

Project Name: Collier Raw Water Pump Station and Tunnel

Project No: 21.23.014

Client: Freese and Nichols, Inc.

pH Meter Verification

Buffer Solution: 4.00 Result: 4.00 Buffer Solution: 7.00 Result: 7.02
Temperature, C: 21.2 Temperature, C: 21.1

Buffer Solution: 10.00 Result: 10.05 Buffer Solution: _____ Result: _____
Temperature, C: 21.0 Temperature, C: _____

Sample No.	pH	Temperature, C
TB-1 (2'-4')	8.34	20.5
TB-4 (4.5'-6')	6.16	20.5
TB-9 (2'-4')	4.42	20.4
TB-12 (2'-4')	5.66	20.4
TB-12 (4'-6')	8.69	20.6

pH Meter S/N: C008035300

Thermometer S/N: C008035300

Tested By: F. Salas

Date: 3/12/21

Checked By: F. Salas

Date: 3/12/21



TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Client: Tolunay Wong Engineers, Inc.
Project: 21.23.014 - FNI - CoBMT - Collier Raw Water Pump Station

TRI Log #: 62328

Jeffrey A. Kuhn, Ph.D., P.E., 3/22/2021

Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO ₄ /kg)	Chloride Content (mg/kg)
-	Test Method	ASTM C1580	ASTM D512
-	Method Detection Limit (MDL)	[5 mg/l]*	[5 mg/l]*
1	TB-1 (2.0-4.0)	500	120
2	TB-4 (4.5-6.0)	500	90
3	TB-9 (2.0-4.0)	600	270
4	TB-12 (2.0-4.0)	600	60
5	TB-12 (4.0-6.0)	500	60

(1) ND No Detection - Below Method Detection Limit (MDL)

(2) MDL The chloride and sulfate MDLs are volumetric. Results are mass per mass of dry soil.



TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Client: Tolunay Wong Engineers, Inc.
Project: 21.23.014 - FNI - CoBMT - Collier Raw Water Pump Station

TRI Log #: 62476

Jeffrey A. Kuhn, Ph.D., P.E., 3/25/2021

Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO ₄ /kg)	Chloride Content (mg/kg)	pH
-	Test Method	ASTM C1580	ASTM D512	ASTM G51
-	Method Detection Limit (MDL)	[5 mg/l]*	[5 mg/l]*	-
1	TB-11 / 01-2.0	3,300	150	7.16

- (1) ND No Detection - Below Method Detection Limit (MDL)
(2) MDL The chloride and sulfate MDLs are volumetric. Results are mass per mass of dry soil.



TESTING, RESEARCH, CONSULTING AND FIELD SERVICES

Austin, TX - USA | CA - USA | SC - USA | Gold Coast - Australia | Suzhou - China | Sao Paulo, Brazil | Johannesburg - Africa

Client: Tolunay Wong Engineers, Inc.
Project: 21.23.014 - FNI - CoBMT - Collier Raw Water Pump Station

TRI Log #: 62004

Jeffrey A. Kuhn, Ph.D., P.E., 3/2/2021

Quality Review/Date

Analytical

COC Line #	Sample Identification	Sulfate Content (mg SO ₄ /kg)	Chloride Content (mg/kg)	pH
-	Test Method	ASTM C1580	ASTM D512	ASTM G51
-	Method Detection Limit (MDL)	[5 mg/l]*	[5 mg/l]*	-
1	TB-6 (4.0-6.0)	900	240	9.75

- (1) ND No Detection - Below Method Detection Limit (MDL)
- (2) MDL The chloride and sulfate MDLs are volumetric. Results are mass per mass of dry soil.

THERMAL CONDUCTIVITY TEST RESULTS

Tolunay-Wong Engineers, Inc.

10710 S. Sam Houston Pkwy. W, Suite 100 Houston, TX 77031

THERMAL CONDUCTIVITY - ASTM D5334

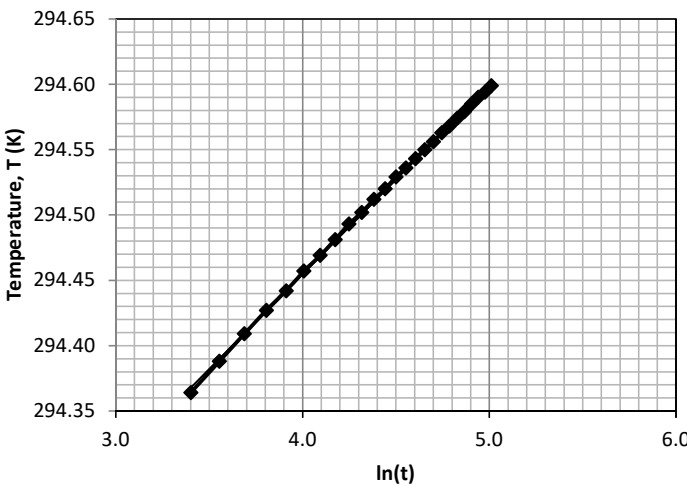
Project Number	21.23.014	Date	03/24/21
Sample Identification	TB-1.6-8	Technician	PK
Soil Classification	CLAYEY SAND (SC)		

Water Content		Weight/Volume Relationship			
Tare No.	AD-OO	Diam. of Sample, in.	2.802	Void Ratio	0.51
Wet Weight + Tare, g	159.57	Height of Sample, in.	5.676	Porosity, %	33.90
Dry Weight + Tare, g	140.26	Specific Gravity (est)	2.70	Saturation, %	92.10
Weight of Tare, g	30.08	Sample Weight, gm	1203.16	Wet Unit Weight, pcf	130.90
Water Content, %	17.50	Sample Area, in ²	6.17	Dry Unit Weight, pcf	111.40

Equipment Identification and Calibration

Manufacturer	Decagon	Calibration Verification - SE2043/03683				Calibration
Model No.	KD2 Pro	CAS No.	Std - W/m-K	Temp C	Rdg - W/m-K	Pass/Fail
Serial Number	KP1296	None	0.933	20.4	1.025	Pass
						Factor, C
						0.910

Test Method and Probe				Thermal Conductivity Test Results	
Thermal Probe	Decagon TR-1	$Q = i^2 R/L$, W/m	4.690	Slope, heating phase	0.15
Length, L, meters	0.1	Current, I, Amps	0.095	Slope, cooling phase	0.16
Pushed/Pre-drilled	Pushed	Resistance, R, Ohms	52.08	Average Slope, heating & cooling	0.15
Time (min)	5			Thermal Conductivity, W/m-K	2.22

Test Measurements				Heating Data	
Heating Phase		Cooling Phase			
Elapsed Time (sec)	Temp., T (K)	Elapsed Time (sec)	Temp., T (K)		
5.0	294.05	155.0	294.04		
10.0	294.19	160.0	293.91		
15.0	294.25	165.0	293.85		
20.0	294.30	170.0	293.80		
25.0	294.34	175.0	293.77		
30.0	294.36	180.0	293.75		
35.0	294.39	185.0	293.73		
40.0	294.41	190.0	293.71		
45.0	294.43	195.0	293.70		
50.0	294.44	200.0	293.68		
55.0	294.46	205.0	293.67		
60.0	294.47	210.0	293.66		
65.0	294.48	215.0	293.65		
70.0	294.49	220.0	293.64		
75.0	294.50	225.0	293.64		
80.0	294.51	230.0	293.63		
85.0	294.52	235.0	293.62		
90.0	294.53	240.0	293.62		
95.0	294.54	245.0	293.61		
100.0	294.54	250.0	293.61		
105.0	294.55	255.0	293.60		
110.0	294.56	260.0	293.60		
115.0	294.56	265.0	293.59		
120.0	294.57	270.0	293.59		
125.0	294.57	275.0	293.59		
130.0	294.58	280.0	293.58		
135.0	294.59	285.0	293.58		
140.0	294.59	290.0	293.58		
145.0	294.59	295.0	293.58		
150.0	294.60	300.0	293.57		
Calculated By PK				Checked By EEH	
Date 03/24/21				Date 03/25/21	

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THERMAL CONDUCTIVITY - ASTM D5334

Project Number	21.23.014	Date	02/26/21
Sample Identification	TB-5, 4-6	Technician	PK
Soil Classification	Sandy Lean Clay (CL)		

Water Content		Weight/Volume Relationship			
Tare No.	196	Diam. of Sample, in.	2.975	Void Ratio	0.78
Wet Weight + Tare, g	132.2	Height of Sample, in.	5.125	Porosity, %	43.90
Dry Weight + Tare, g	111.91	Specific Gravity (est)	2.70	Saturation, %	86.70
Weight of Tare, g	31.20	Sample Weight, gm	1107.74	Wet Unit Weight, pcf	118.40
Water Content, %	25.10	Sample Area, in ²	6.95	Dry Unit Weight, pcf	94.60

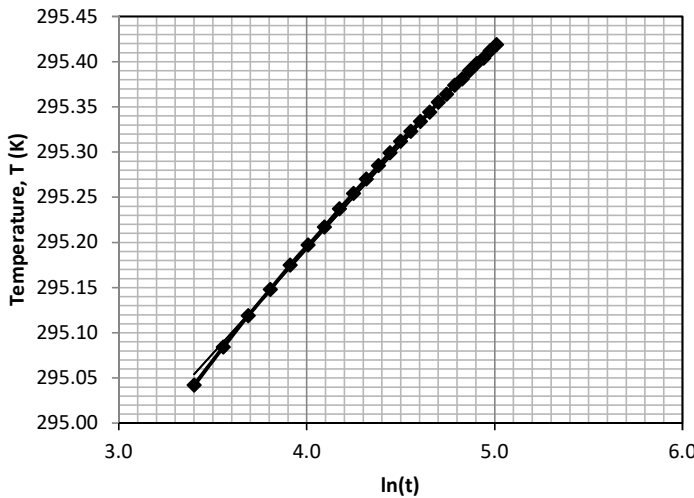
Equipment Identification and Calibration

Manufacturer	Decagon	Calibration Verification - SE2043/03683					Calibration
Model No.	KD2 Pro	CAS No.	Std - W/m-K	Temp C	Rdg - W/m-K	Pass/Fail	Factor, C
Serial Number	KP1296	None	0.933	20.0	1.021	Pass	0.914

Test Method and Probe				Thermal Conductivity Test Results	
Thermal Probe	Decagon TR-1	$Q = i^2 R/L$, W/m	4.810	Slope, heating phase	0.23
Length, L, meters	0.1	Current, I, Amps	0.096	Slope, cooling phase	0.26
Pushed/Pre-drilled	Pushed	Resistance, R, Ohms	51.98	Average Slope, heating & cooling	0.25
Time (min)	5			Thermal Conductivity, W/m-K	1.42

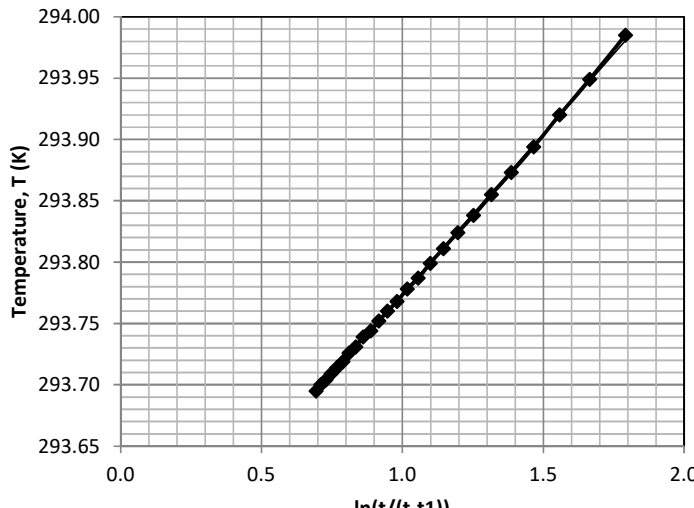
Test Measurements			
Heating Phase		Cooling Phase	
Elapsed Time (sec)	Temp., T (K)	Elapsed Time (sec)	Temp., T (K)
5.0	294.33	155.0	294.62
10.0	294.66	160.0	294.32
15.0	294.82	165.0	294.18
20.0	294.92	170.0	294.09
25.0	294.99	175.0	294.03
30.0	295.04	180.0	293.99
35.0	295.08	185.0	293.95
40.0	295.12	190.0	293.92
45.0	295.15	195.0	293.89
50.0	295.18	200.0	293.87
55.0	295.20	205.0	293.86
60.0	295.22	210.0	293.84
65.0	295.24	215.0	293.82
70.0	295.25	220.0	293.81
75.0	295.27	225.0	293.80
80.0	295.29	230.0	293.79
85.0	295.30	235.0	293.78
90.0	295.31	240.0	293.77
95.0	295.32	245.0	293.76
100.0	295.33	250.0	293.75
105.0	295.34	255.0	293.74
110.0	295.36	260.0	293.74
115.0	295.36	265.0	293.73
120.0	295.37	270.0	293.73
125.0	295.38	275.0	293.72
130.0	295.39	280.0	293.71
135.0	295.40	285.0	293.71
140.0	295.40	290.0	293.70
145.0	295.41	295.0	293.70
150.0	295.42	300.0	293.70

Heating Data



ln(t)	Temperature T (K)
3.45	295.04
3.59	295.08
3.73	295.12
3.87	295.15
4.01	295.18
4.15	295.20
4.29	295.22
4.43	295.24
4.57	295.25
4.71	295.27
4.85	295.29
4.99	295.30
5.13	295.31
5.27	295.32
5.41	295.33
5.55	295.34
5.69	295.36
5.83	295.36
5.97	295.37
6.11	295.38
6.25	295.39
6.39	295.40
6.53	295.40
6.67	295.41
6.81	295.42

Cooling Data



ln(t/(t-t1))	Temperature T (K)
0.68	293.69
0.72	293.70
0.76	293.71
0.80	293.72
0.84	293.73
0.88	293.74
0.92	293.75
0.96	293.76
1.00	293.77
1.04	293.78
1.08	293.79
1.12	293.80
1.16	293.81
1.20	293.82
1.24	293.83
1.28	293.84
1.32	293.85
1.36	293.86
1.40	293.87
1.44	293.88
1.48	293.89
1.52	293.90
1.56	293.92
1.60	293.94
1.64	293.95
1.68	293.96
1.72	293.97
1.76	293.98
1.80	293.99

Calculated By	PK	Checked By	EEH
Date	02/26/21	Date	03/01/21

Tolunay-Wong Engineers, Inc.

10710 S. Sam Houston Pkwy. W, Suite 100 Houston, TX 77031

THERMAL CONDUCTIVITY - ASTM D5334

Project Number	21.23.014	Date	02/25/21
Sample Identification	TB-8, 2-4	Technician	PK
Soil Classification	Sandy Lean Clay (CL)		

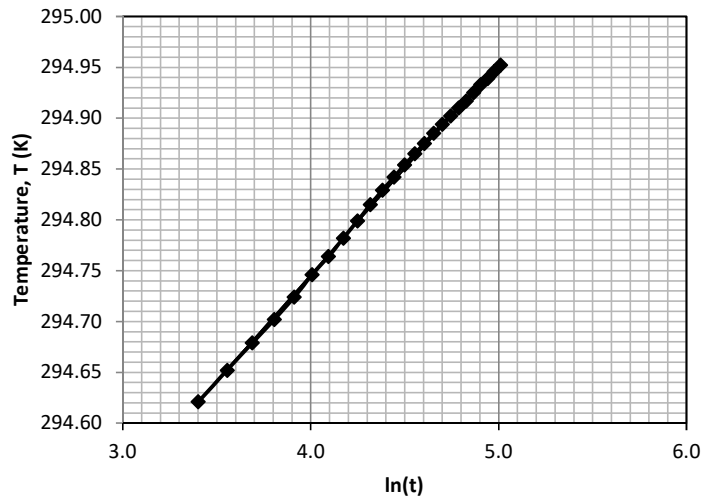
Water Content		Weight/Volume Relationship			
Tare No.	EB-2	Diam. of Sample, in.	2.8	Void Ratio	0.44
Wet Weight + Tare, g	158.7	Height of Sample, in.	5.269	Porosity, %	30.50
Dry Weight + Tare, g	140.66	Specific Gravity (est)	2.70	Saturation, %	101.10
Weight of Tare, g	30.61	Sample Weight, gm	1161.87	Wet Unit Weight, pcf	136.40
Water Content, %	16.40	Sample Area, in ²	6.16	Dry Unit Weight, pcf	117.20

Equipment Identification and Calibration							
Manufacturer	Decagon	Calibration Verification - SE2043/03683					Calibration
Model No.	KD2 Pro	CAS No.	Std - W/m-K	Temp C	Rdg - W/m-K	Pass/Fail	Factor, C
Serial Number	KP1296	None	0.933	20.0	1.021	Pass	0.914

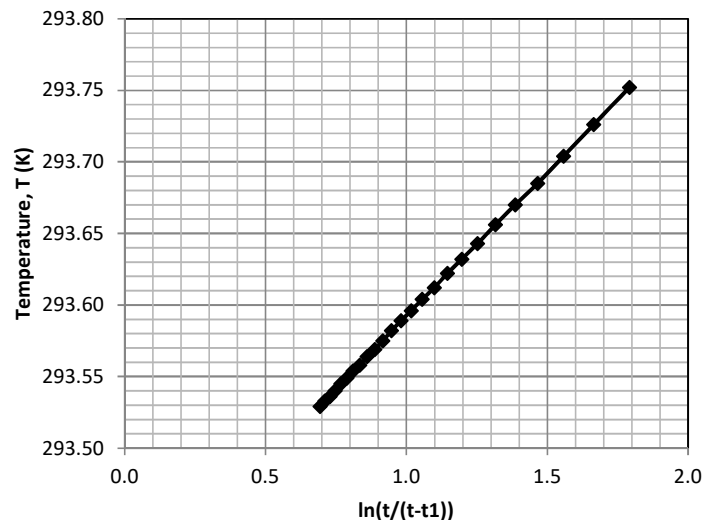
Test Method and Probe				Thermal Conductivity Test Results	
Thermal Probe	Decagon TR-1	$Q = i^2 R/L$, W/m	4.760	Slope, heating phase	0.21
Length, L, meters	0.1	Current, I, Amps	0.096	Slope, cooling phase	0.20
Pushed/Pre-drilled	Pushed	Resistance, R, Ohms	52.08	Average Slope, heating & cooling	0.21
Time (min)	5			Thermal Conductivity, W/m-K	1.67

Test Measurements			
Heating Phase		Cooling Phase	
Elapsed Time (sec)	Temp., T (K)	Elapsed Time (sec)	Temp., T (K)
5.0	294.16	155.0	294.21
10.0	294.39	160.0	293.98
15.0	294.48	165.0	293.89
20.0	294.54	170.0	293.83
25.0	294.59	175.0	293.79
30.0	294.62	180.0	293.75
35.0	294.65	185.0	293.73
40.0	294.68	190.0	293.70
45.0	294.70	195.0	293.69
50.0	294.72	200.0	293.67
55.0	294.75	205.0	293.66
60.0	294.76	210.0	293.64
65.0	294.78	215.0	293.63
70.0	294.80	220.0	293.62
75.0	294.82	225.0	293.61
80.0	294.83	230.0	293.60
85.0	294.84	235.0	293.60
90.0	294.85	240.0	293.59
95.0	294.87	245.0	293.58
100.0	294.88	250.0	293.58
105.0	294.89	255.0	293.57
110.0	294.89	260.0	293.56
115.0	294.90	265.0	293.56
120.0	294.91	270.0	293.55
125.0	294.92	275.0	293.55
130.0	294.93	280.0	293.55
135.0	294.93	285.0	293.54
140.0	294.94	290.0	293.54
145.0	294.95	295.0	293.53
150.0	294.95	300.0	293.53

Heating Data



Cooling Data



Calculated By	PK	Checked By	EEH
Date	02/26/21	Date	02/26/21

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Tolunay-Wong Engineers, Inc.

10710 S. Sam Houston Pkwy. W, Suite 100 Houston, TX 77031

THERMAL CONDUCTIVITY - ASTM D5334

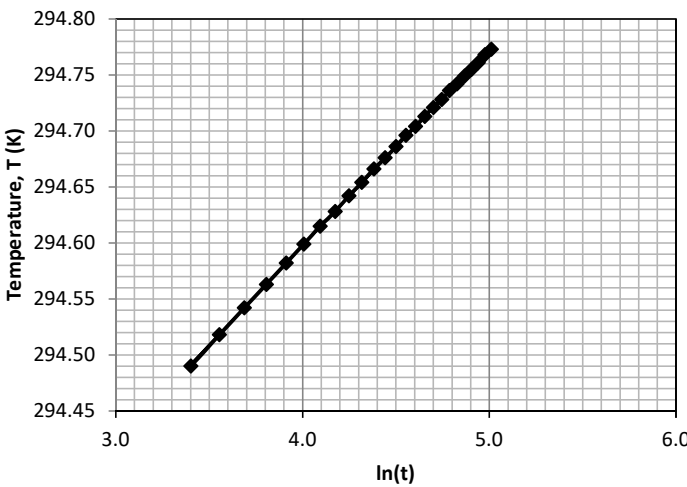
Project Number	21.23.014	Date	03/11/21
Sample Identification	TB-13/PZ-13, 4-6	Technician	PK
Soil Classification	LEAN CLAY (CL)		

Water Content		Weight/Volume Relationship			
Tare No.	5	Diam. of Sample, in.	2.846	Void Ratio	0.52
Wet Weight + Tare, g	381.52	Height of Sample, in.	5.732	Porosity, %	34.00
Dry Weight + Tare, g	364.04	Specific Gravity (est)	2.70	Saturation, %	91.00
Weight of Tare, g	263.55	Sample Weight, gm	1249.4	Wet Unit Weight, pcf	130.50
Water Content, %	17.40	Sample Area, in ²	6.36	Dry Unit Weight, pcf	111.20

Equipment Identification and Calibration

Manufacturer	Decagon	Calibration Verification - SE2043/03683				Calibration
Model No.	KD2 Pro	CAS No.	Std - W/m-K	Temp C	Rdg - W/m-K	Pass/Fail
Serial Number	KP1296	None	1.140	20.6	1.052	Pass
						Factor, C
						1.084

Test Method and Probe				Thermal Conductivity Test Results	
Thermal Probe	Decagon TR-1	$Q = i^2 R/L$, W/m	4.240	Slope, heating phase	0.18
Length, L, meters	0.1	Current, I, Amps	0.090	Slope, cooling phase	0.20
Pushed/Pre-drilled	Pushed	Resistance, R, Ohms	52.00	Average Slope, heating & cooling	0.19
Time (min)	5			Thermal Conductivity, W/m-K	1.96

Test Measurements				Heating Data	
Heating Phase		Cooling Phase			
Elapsed Time (sec)	Temp., T (K)	Elapsed Time (sec)	Temp., T (K)		
5.0	294.11	155.0	294.23		
10.0	294.28	160.0	294.10		
15.0	294.36	165.0	294.03		
20.0	294.42	170.0	293.98		
25.0	294.46	175.0	293.95		
30.0	294.49	180.0	293.92		
35.0	294.52	185.0	293.90		
40.0	294.54	190.0	293.88		
45.0	294.56	195.0	293.86		
50.0	294.58	200.0	293.84		
55.0	294.60	205.0	293.83		
60.0	294.62	210.0	293.82		
65.0	294.63	215.0	293.81		
70.0	294.64	220.0	293.80		
75.0	294.65	225.0	293.79		
80.0	294.67	230.0	293.78		
85.0	294.68	235.0	293.77		
90.0	294.69	240.0	293.76		
95.0	294.70	245.0	293.76		
100.0	294.70	250.0	293.75		
105.0	294.71	255.0	293.74		
110.0	294.72	260.0	293.74		
115.0	294.73	265.0	293.73		
120.0	294.74	270.0	293.73		
125.0	294.74	275.0	293.73		
130.0	294.75	280.0	293.72		
135.0	294.76	285.0	293.72		
140.0	294.76	290.0	293.71		
145.0	294.77	295.0	293.71		
150.0	294.77	300.0	293.71		
Calculated By PK				Checked By EEH	
Date 03/11/21				Date 03/12/21	

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ONE-DIMENSIONAL SWELL TEST RESULTS

SWELL TEST REPORT

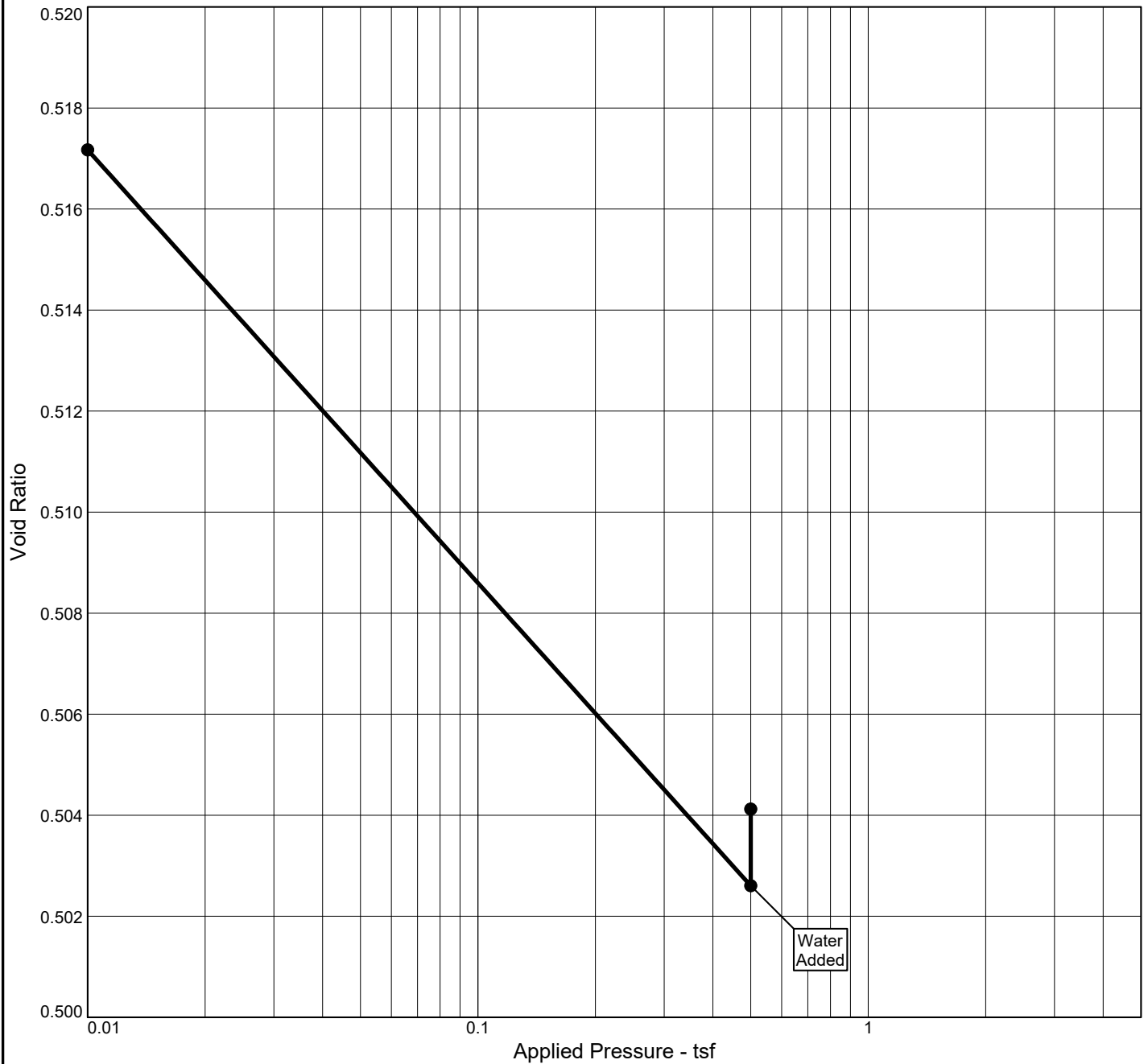
Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	e_o	Swell Press. (tsf)	Swell %	C_r
Sat.	Moist.									
91.6 %	18.7 %	108.6			2.70	.125	0.552		0.1	

MATERIAL DESCRIPTION								USCS	AASHTO
CLAYEY SAND								SC	

Project No. 21.23.014	Client: Freese and Nichols, Inc.	Remarks: ASTM D4546 - Method B Specific Gravity: Assumed
Project: Collier Raw Water Pump Station and Tunnel Beaumont, Texas		
Source of Sample: TB-1 SWELL	Depth: 2	
Tolunay-Wong Engineers, Inc. Houston, Texas		

Tested By: B. Moore

SWELL TEST REPORT



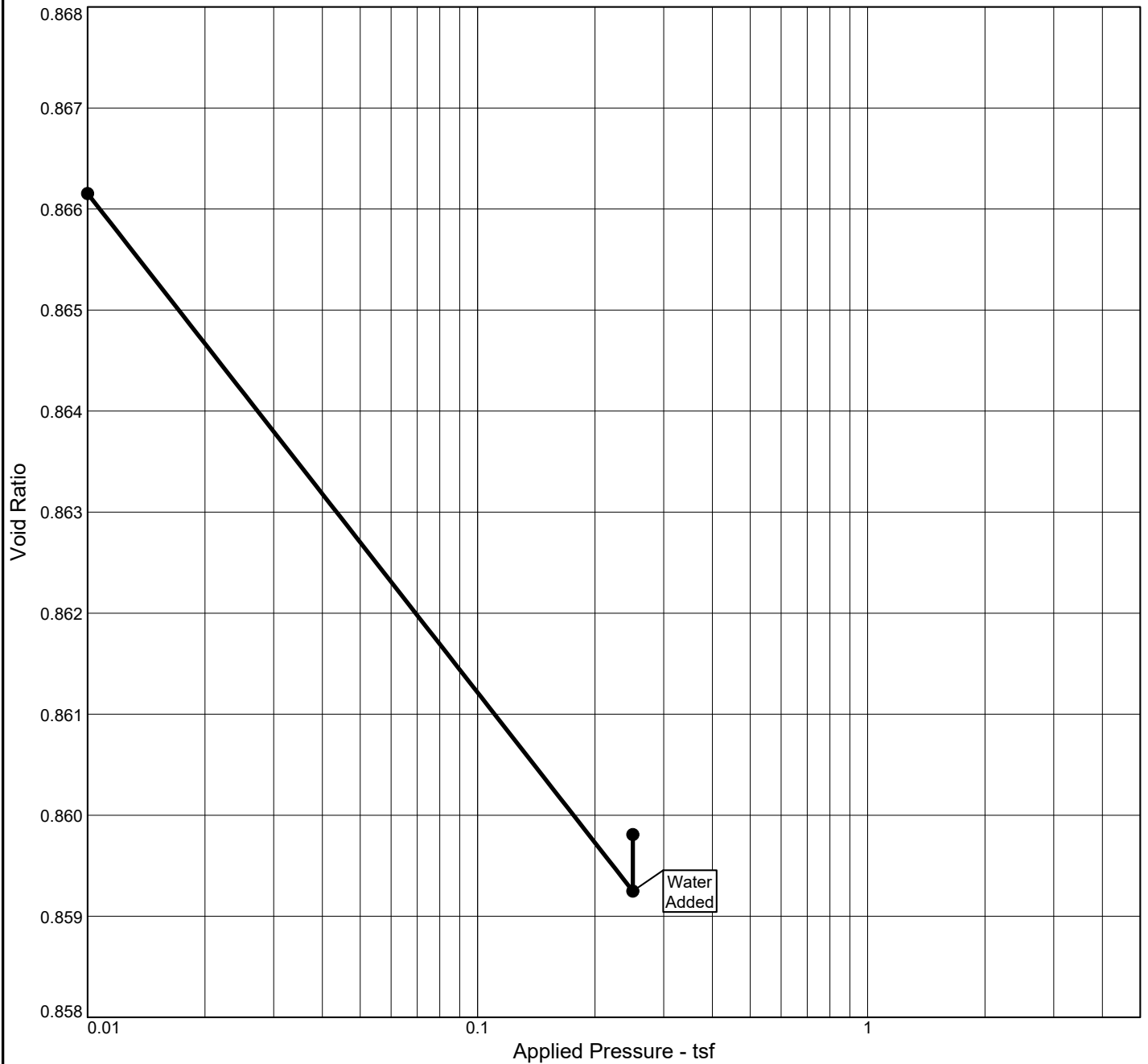
Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	e _o	Swell Press. (tsf)	Swell %	C _r
Sat.	Moist.									
93.5 %	17.9 %	111.1	31	15	2.70	0.25	0.517		0.1	

MATERIAL DESCRIPTION									USCS	AASHTO
CLAYEY SAND									SC	

Project No. 21.23.014						Client: Freese and Nichols, Inc.						Remarks: ASTM D4546 - Method B Specific Gravity: Assumed % Passing #200 = 38
Project: Collier Raw Water Pump Station and Tunnel Beaumont, Texas												
Source of Sample: TB-2 SWELL						Depth: 4						
Tolunay-Wong Engineers, Inc.												
Houston, Texas												Figure

Tested By: B. Moore

SWELL TEST REPORT



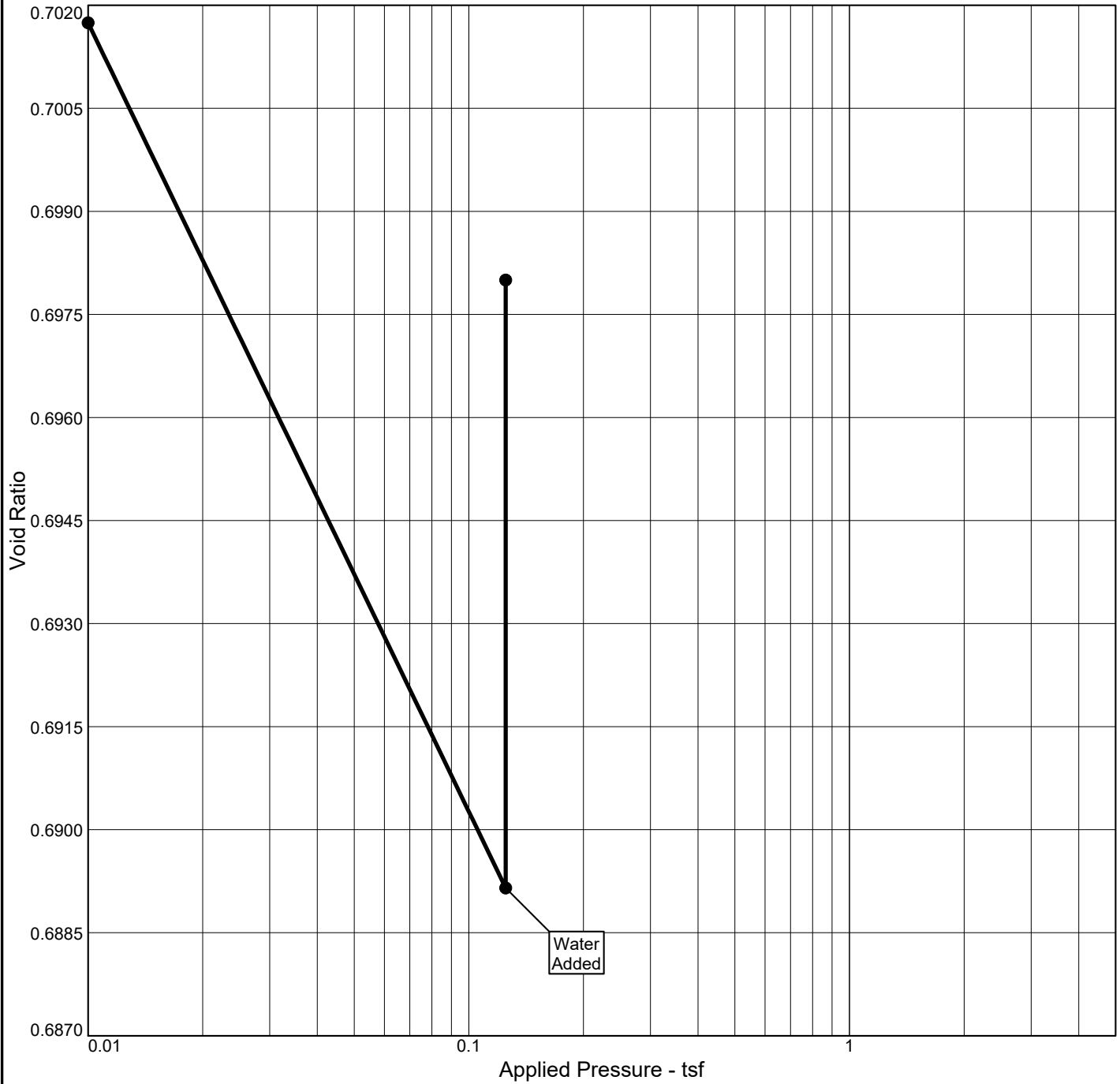
Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	e_o	Swell Press. (tsf)	Swell %	C_r
Sat.	Moist.									
108.1 %	34.7 %	90.3			2.70	0.25	0.866		0.0	

MATERIAL DESCRIPTION								USCS	AASHTO
FAT CLAY								CH	

Project No. 21.23.014		Client: Freese and Nichols, Inc.		Remarks: ASTM D4546 - Method B Specific Gravity: Assumed
Project: Collier Raw Water Pump Station and Tunnel Beaumont, Texas				
Source of Sample: TB-6 SWELL		Depth: 4		
Tolunay-Wong Engineers, Inc.				
Houston, Texas				Figure

Tested By: B. Moore

SWELL TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	e _o	Swell Press. (tsf)	Swell %	C _r
Sat.	Moist.									
95.4 %	24.8 %	99.0			2.70	0.125	0.702		0.5	

MATERIAL DESCRIPTION	USCS	AASHTO
FAT CLAY with SAND	CH	

Project No. 21.23.014 Client: Freese and Nichols, Inc. Project: Collier Raw Water Pump Station and Tunnel Beaumont, Texas Source of Sample: TB-9 SWELL Depth: 2	Remarks: ASTM D4546 - Method B Specific Gravity: Assumed
<div style="text-align: center;"> Tolunay-Wong Engineers, Inc. Houston, Texas </div>	

SWELL TEST REPORT

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	e _o	Swell Press. (tsf)	Swell %	C _r
Sat.	Moist.									
93.2 %	18.0 %	110.8	44	31	2.70	0.375	0.522		1.2	

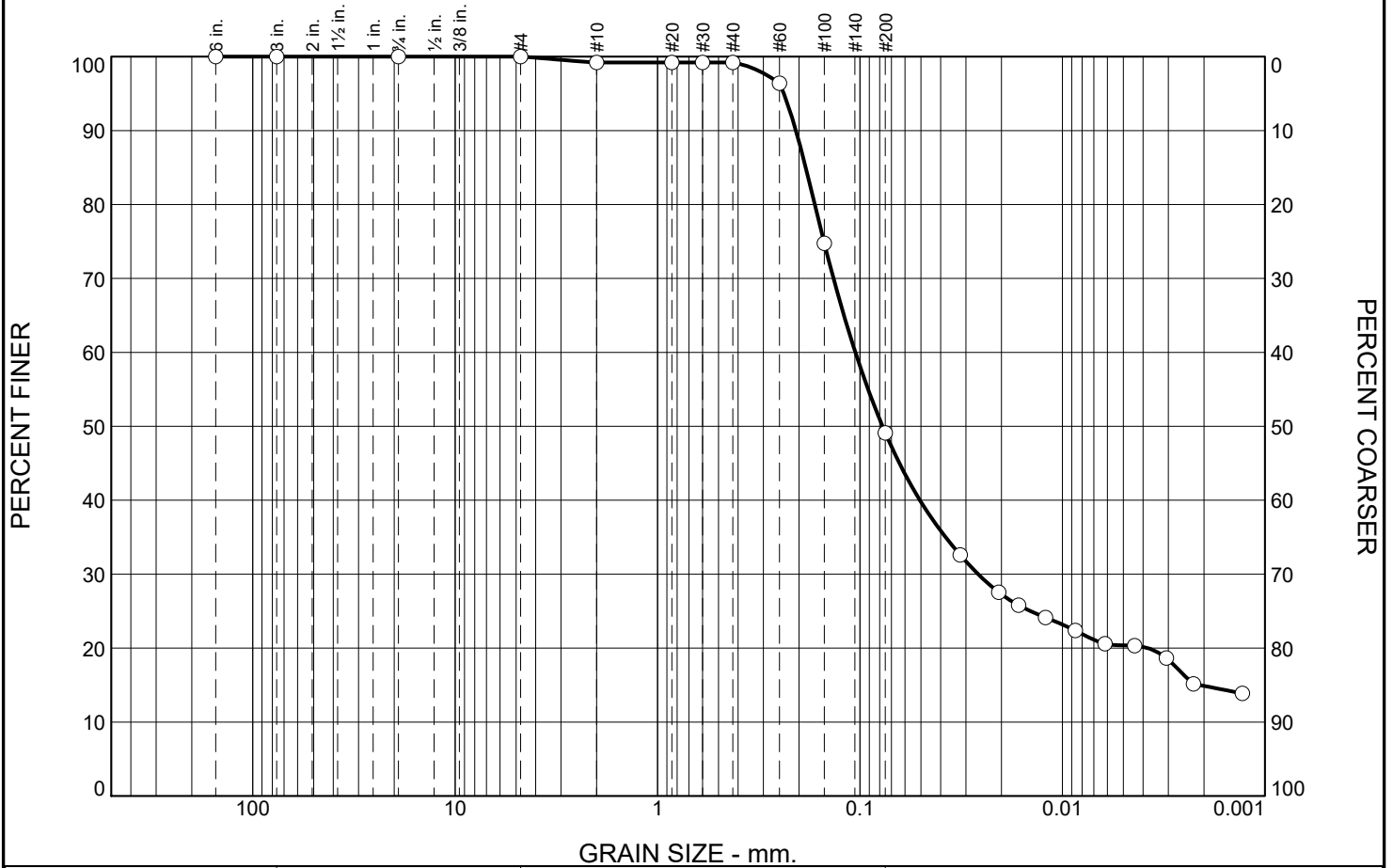
MATERIAL DESCRIPTION								USCS	AASHTO
SANDY LEAN CLAY								CL	

Project No. 21.23.014		Client: Freese and Nichols, Inc.		Remarks: ASTM D4546 - Method B Specific Gravity: Assumed % Passing #200 = 59
Project: Collier Raw Water Pump Station and Tunnel Beaumont, Texas				
Source of Sample: TB-11 SWELL Depth: 6				
Tolunay-Wong Engineers, Inc.				Figure
Houston, Texas				

Tested By: B. Moore

SIEVE ANALYSIS WITH HYDROMETER TEST RESULTS

ASTM D422



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.8	0.0	50.1	28.7	20.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
6"	100.0		
3"	100.0		
3/4"	100.0		
#4	100.0		
#10	99.2		
#20	99.2		
#30	99.2		
#40	99.2		
#60	96.4		
#100	74.7		
#200	49.1		

* (no specification provided)

Material Description
CLAYEY SAND

Atterberg Limits
PL= LL= PI=

Classification
USCS= SC AASHTO=

Remarks

Source of Sample: TB-1

Depth: 12

Date:

**Tolunay-Wong
Engineers, Inc.
Houston, Texas**

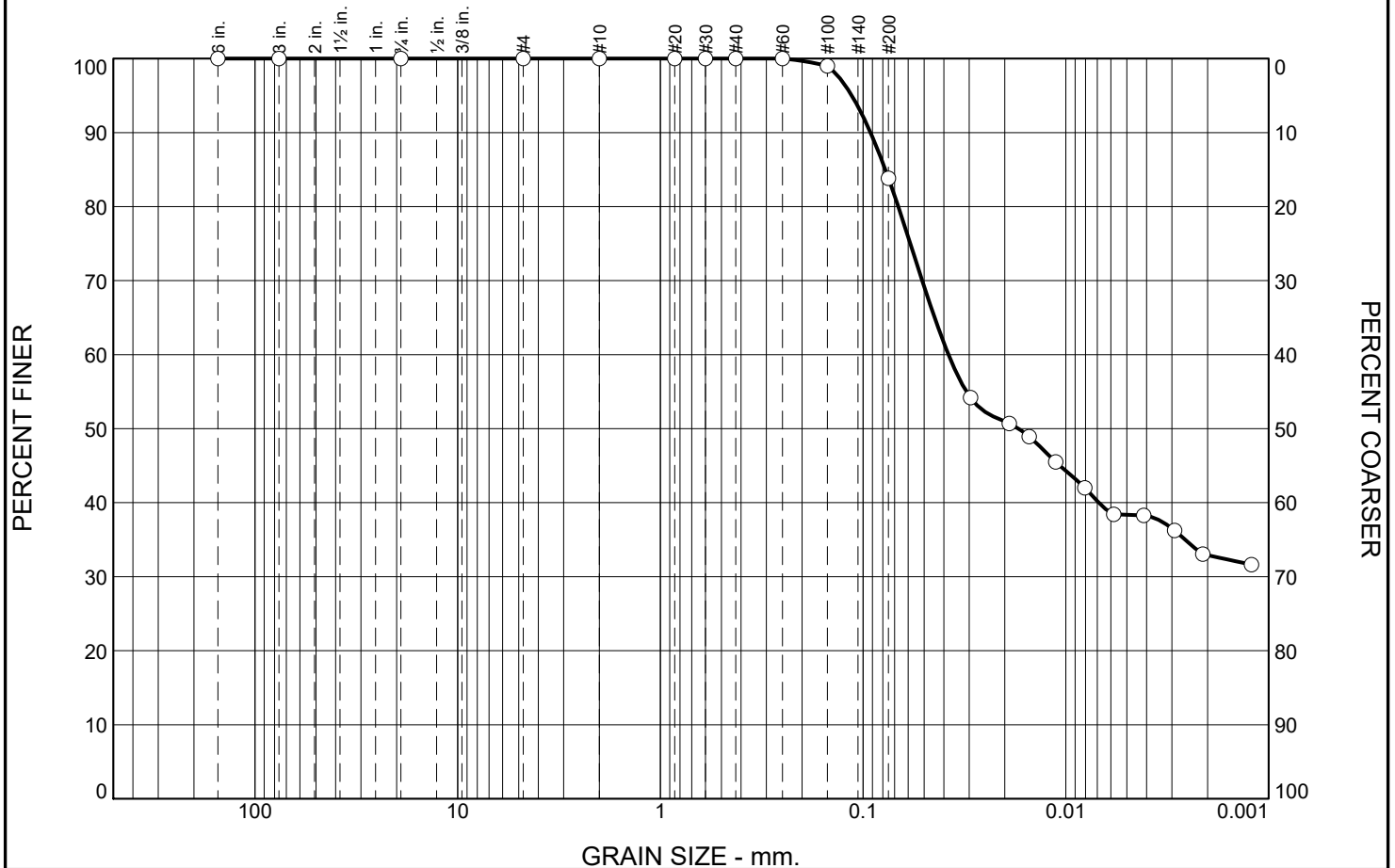
Client: Freese and Nichols, Inc.

Project: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

Project No: 21.23.014

Figure

ASTM D422



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	16.2	45.4	38.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
6"	100.0		
3"	100.0		
3/4"	100.0		
#4	100.0		
#10	100.0		
#20	100.0		
#30	100.0		
#40	100.0		
#60	100.0		
#100	99.0		
#200	83.8		

* (no specification provided)

Material Description
FAT CLAY with SAND

Atterberg Limits
PL= 28 LL= 71 PI= 43

Classification
USCS= CH AASHTO=

Remarks

Source of Sample: TB-3

Depth: 6

Date:

**Tolunay-Wong
Engineers, Inc.
Houston, Texas**

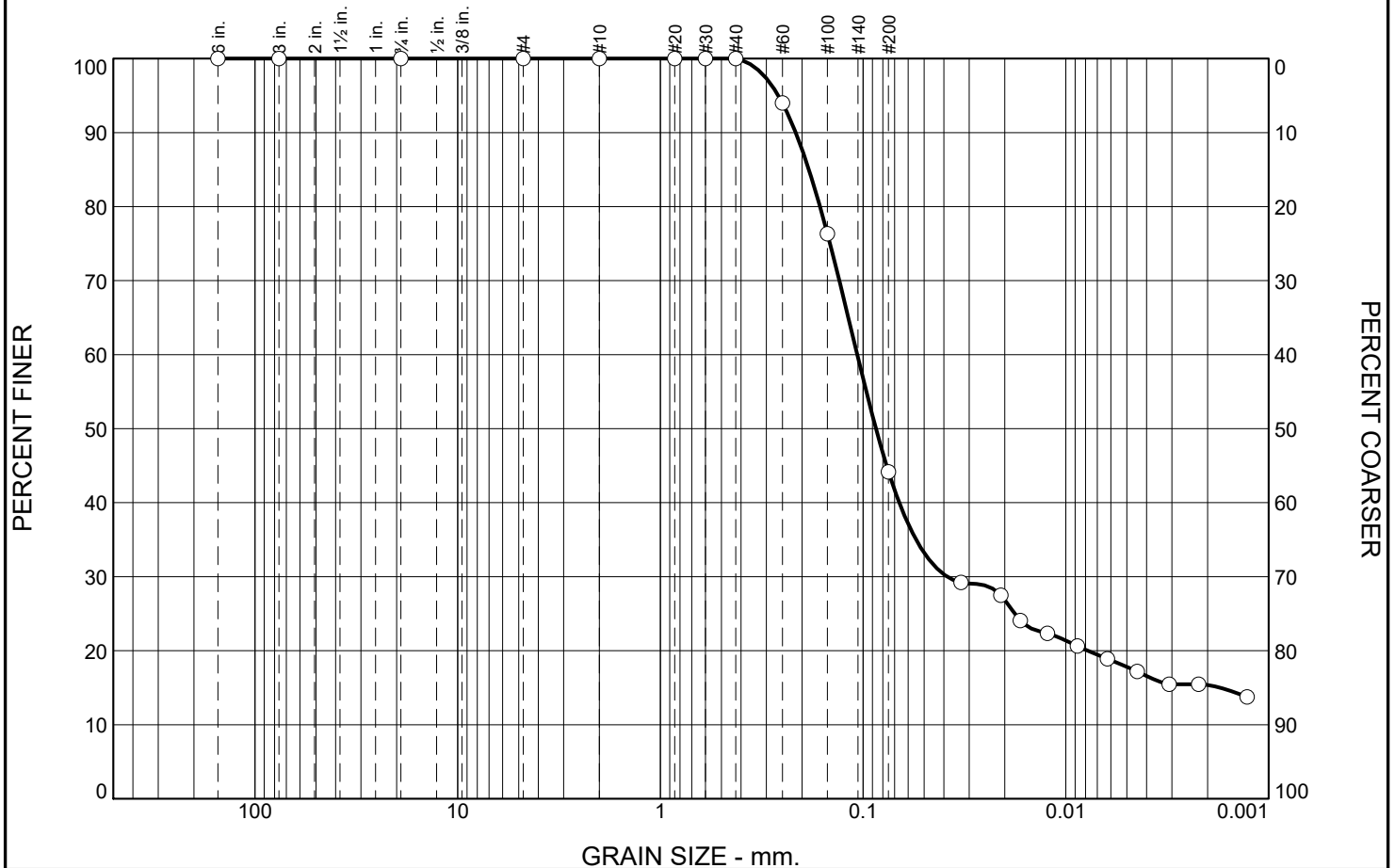
Client: Freese and Nichols, Inc.

Project: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

Project No: 21.23.014

Figure

ASTM D422



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	55.8	26.4	17.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
6"	100.0		
3"	100.0		
3/4"	100.0		
#4	100.0		
#10	100.0		
#20	100.0		
#30	100.0		
#40	100.0		
#60	94.0		
#100	76.3		
#200	44.2		

* (no specification provided)

Material Description
CLAYEY SAND

Atterberg Limits
PL= 23 LL= 68 PI= 45

Classification
USCS= SC AASHTO=

Remarks

Source of Sample: TB-6

Depth: 8

Date:

**Tolunay-Wong
Engineers, Inc.
Houston, Texas**

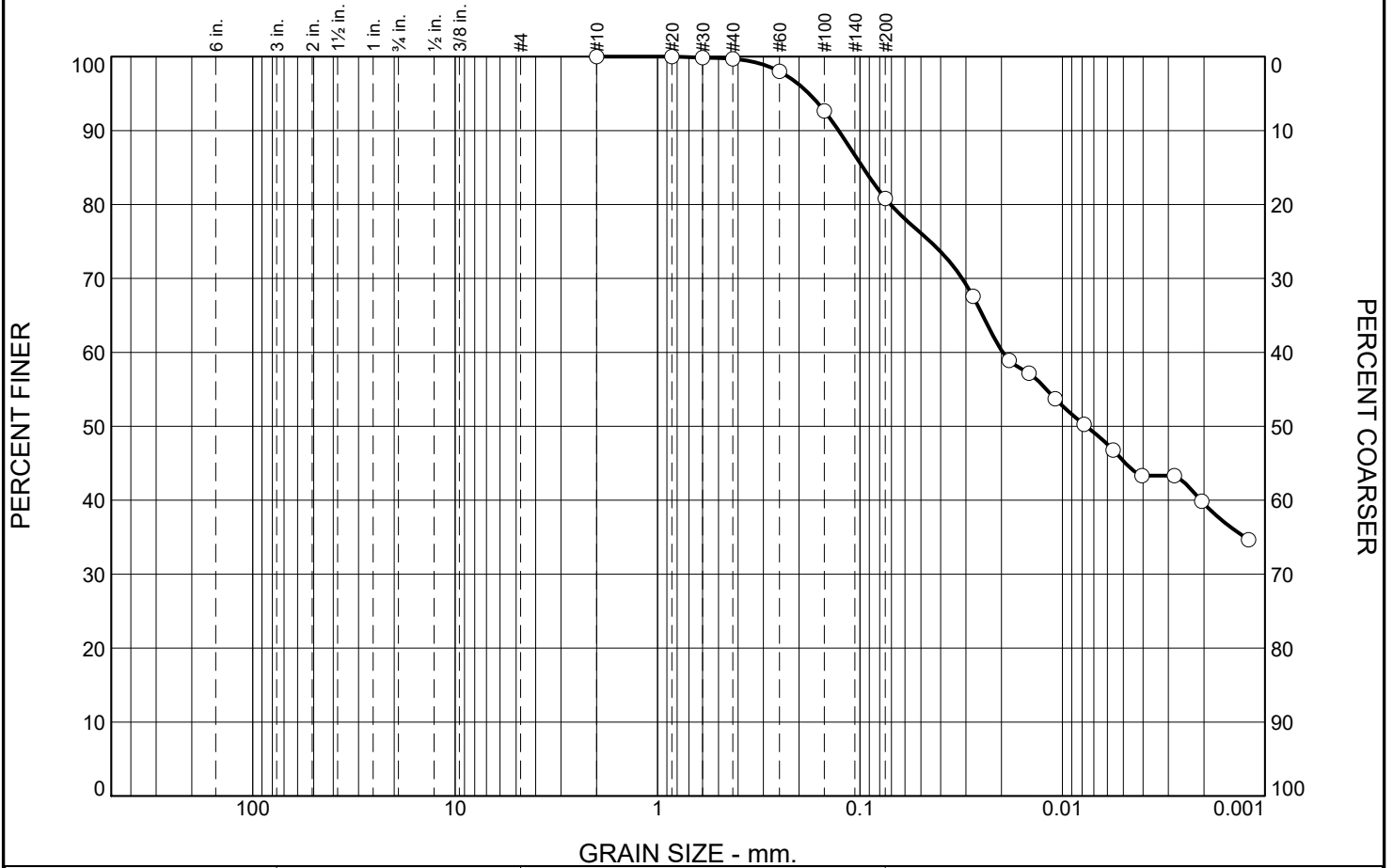
Client: Freese and Nichols, Inc.

Project: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

Project No: 21.23.014

Figure

ASTM D422



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.3	18.9	35.5	45.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#30	99.9		
#40	99.7		
#60	98.0		
#100	92.7		
#200	80.8		

* (no specification provided)

Material Description
 FAT CLAY with SAND

PL= 19 **Atterberg Limits** LL= 59 PI= 40

USCS= CH **Classification** AASHTO=

Remarks

Source of Sample: TB-9

Depth: 4

Date:

**Tolunay-Wong
Engineers, Inc.
Houston, Texas**

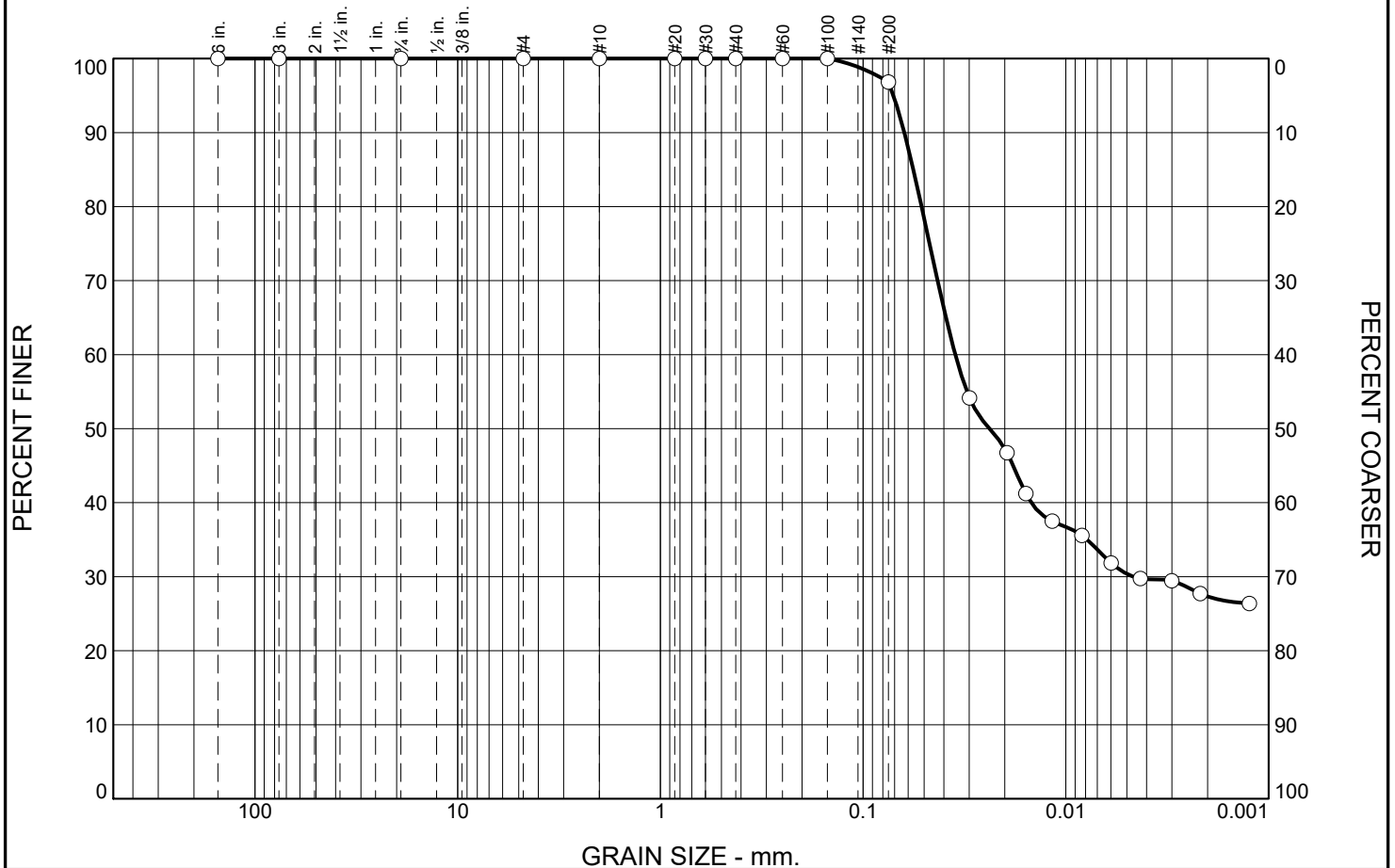
Client: Freese and Nichols, Inc.

Project: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

Project No: 21.23.014

Figure

ASTM D422



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	3.2	66.4	30.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
6"	100.0		
3"	100.0		
3/4"	100.0		
#4	100.0		
#10	100.0		
#20	100.0		
#30	100.0		
#40	100.0		
#60	100.0		
#100	100.0		
#200	96.8		

* (no specification provided)

Material Description

FAT CLAY

Atterberg Limits

PL= 23 LL= 62 PI= 39

Classification

USCS= CH AASHTO=

Remarks

Source of Sample: TB-11

Depth: 16

Date:

**Tolunay-Wong
Engineers, Inc.
Houston, Texas**

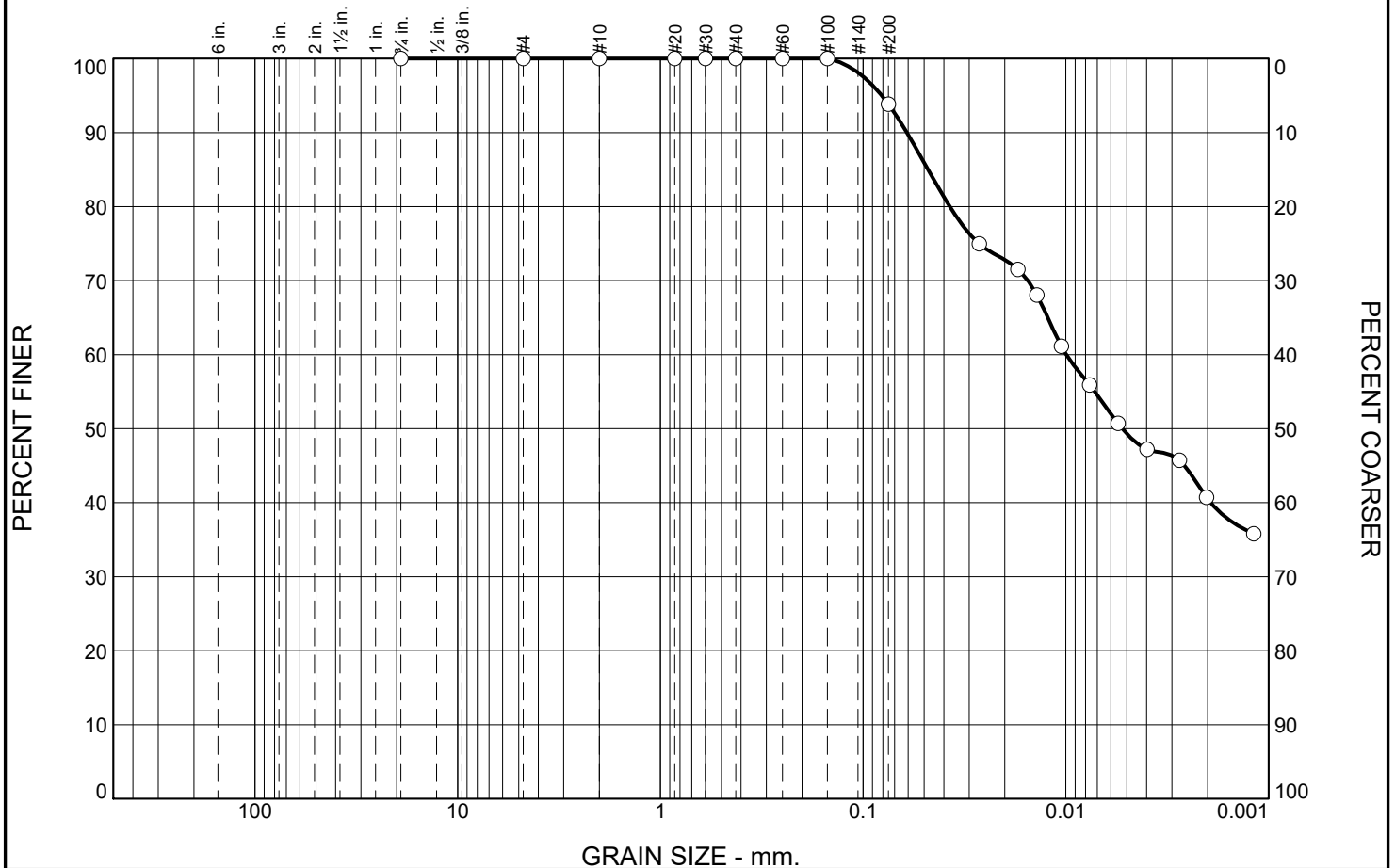
Client: Freese and Nichols, Inc.

Project: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

Project No: 21.23.014

Figure

ASTM D422



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	6.2	44.5	49.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4"	100.0		
#4	100.0		
#10	100.0		
#20	100.0		
#30	100.0		
#40	100.0		
#60	100.0		
#100	100.0		
#200	93.8		

* (no specification provided)

Material Description

FAT CLAY

Atterberg Limits

PL= 17 LL= 74 PI= 57

Classification

USCS= CH AASHTO=

Remarks

Source of Sample: TB-12

Depth: 2

Date:

**Tolunay-Wong
Engineers, Inc.
Houston, Texas**

Client: Freese and Nichols, Inc.

Project: Collier Raw Water Pump Station and Tunnel
Beaumont, Texas

Project No: 21.23.014

Figure

SOIL ABRASIVITY TEST RESULTS



Client:	Tolunay-Wong Engineers, Inc.
Project Name:	FNI CoBMT Collier Raw Water Pump
Project Location:	Beaumont, TX
GTX #:	313650
Test Date:	5/27/2021
Tested By:	tlm
Checked By:	jsc
Boring ID:	TB-5
Sample ID:	---
Depth, ft:	8.5-10

Soil Abrasivity Test

Individual Test Results

Test Number	Soil Abrasivity Test value (mg)
1	31.1
2	30.7
Average	30.9

Sample Classification: High

Soil Abrasivity Test Value Reference Classification Chart

Category	Soil Abrasivity Test value (mg)
Low	≤ 7.0
Medium	7.1 - 21.9
High	≥ 22.0

Notes:

1. GTX's Soil Abrasivity Test is based on Nilsen, B., Dahl, F., Holzhäuser J., Raleigh P., New test methodology for estimating the abrasiveness of soils for TBM tunneling. proceeding of RETC conference 2007: 104- 116.
The trademarked acronyms and terms SAT™ and Soil Abrasion Test™ are unique for test results and calculated indices originating from NTNU/SINTEF and can only be obtained by testing samples at their reference laboratory in Trondheim, Norway.
2. Abrasion test material was provided to GTX by client. The test material was dried at 30°C for 3-4 days until dry. The Soil Abrasion Test pieces are comprised of cutter ring steel.
3. Test was performed at 20 RPM for 1 minute for a total of 20 revolutions.

Client:	Tolunay-Wong Engineers, Inc.
Project Name:	FNI CoBMT Collier Raw Water Pump
Project Location:	Beaumont, TX
GTX #:	313650
Boring ID:	TB-5
Sample ID:	---
Depth, ft:	8.5-10

Soil Abrasivity Test - Sample As-Received



Notes:

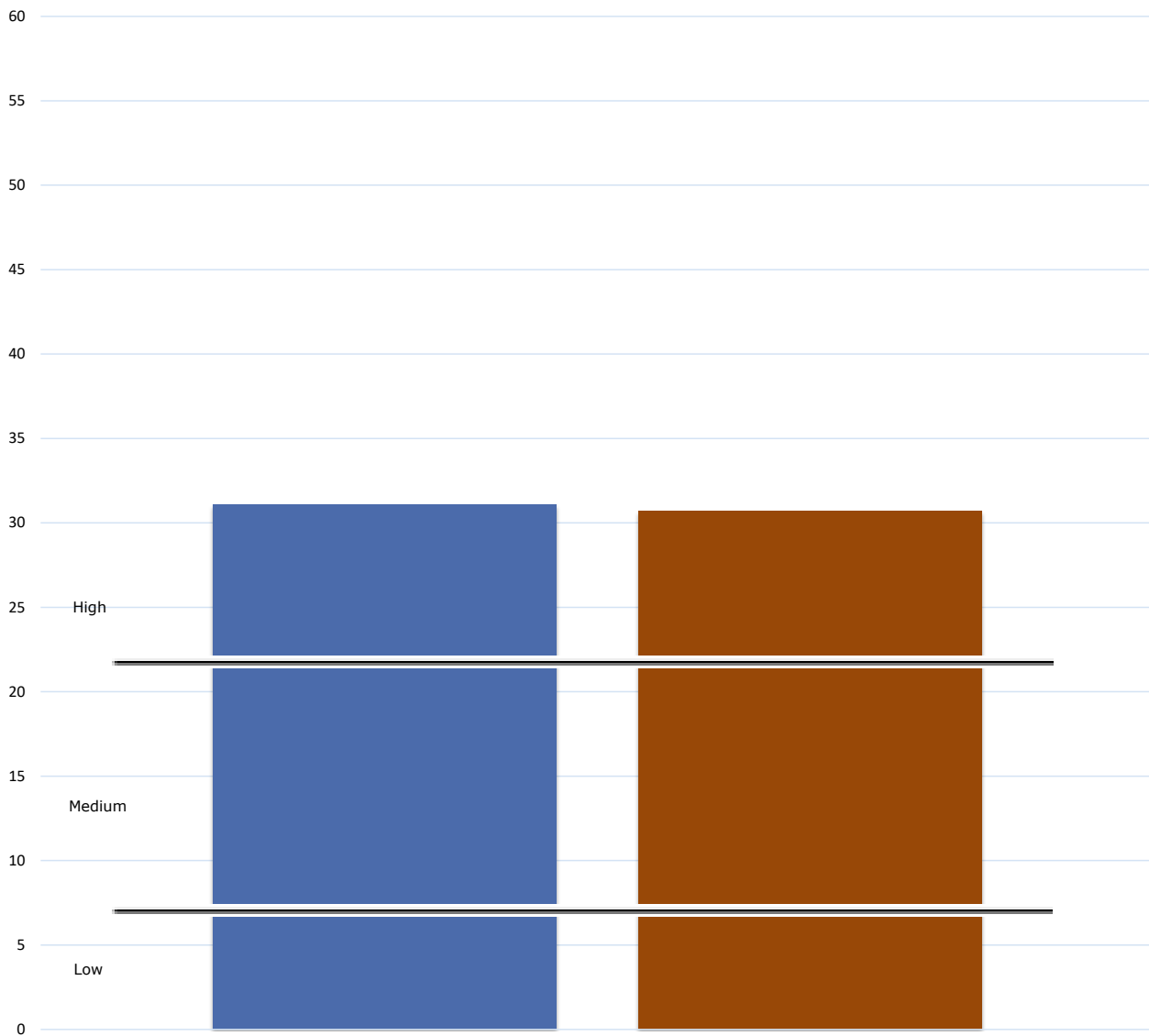
1. GTX's Soil Abrasivity Test is based on Nilsen, B., Dahl, F., Holzhäuser J., Raleigh P., New test methodology for estimating the abrasiveness of soils for TBM tunneling. proceeding of RETC conference 2007: 104- 116. The trademarked acronyms and terms SAT™ and Soil Abrasion Test™ are unique for test results and calculated indices originating from NTNU/SINTEF and can only be obtained by testing samples at their reference laboratory in Trondheim, Norway.



Client:	Tolunay-Wong Engineers, Inc.
Project Name:	FNI CoBMT Collier Raw Water Pump
Project Location:	Beaumont, TX
GTX #:	313650
Test Date:	5/27/2021
Tested By:	tlm
Checked By:	jsc
Boring ID:	TB-5
Sample ID:	---
Depth, ft:	8.5-10

Soil Abrasivity Test

Soil Abrasivity Test Values



Notes: 1. GTX's Soil Abrasivity Test is based on Nilsen, B., Dahl, F., Holzhäuser J., Raleigh P., New test methodology for estimating the abrasiveness of soils for TBM tunneling. proceeding of RETC conference 2007: 104- 116.
The trademarked acronyms and terms SAT™ and Soil Abrasion Test™ are unique for test results and calculated indices originating from NTNU/SINTEF and can only be obtained by testing samples at their reference laboratory in Trondheim, Norway.



Client:	Tolunay-Wong Engineers, Inc.
Project Name:	FNI CoBMT Collier Raw Water Pump
Project Location:	Beaumont, TX
GTX #:	313650
Test Date:	5/27/2021
Tested By:	tlm
Checked By:	jsc
Boring ID:	TB-5
Sample ID:	---
Depth, ft:	10.5-12

Soil Abrasivity Test

Individual Test Results

Test Number	Soil Abrasivity Test value (mg)
1	43.1
2	42.1
Average	42.6

Sample Classification: High

Soil Abrasivity Test Value Reference Classification Chart

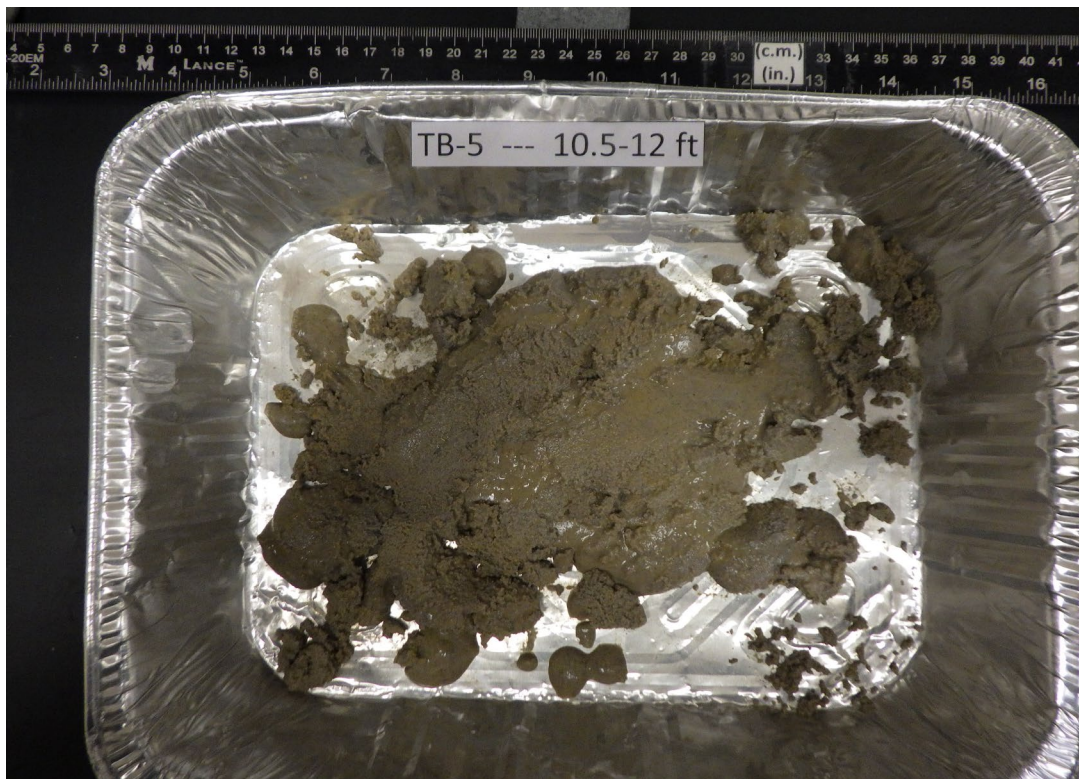
Category	Soil Abrasivity Test value (mg)
Low	≤ 7.0
Medium	7.1 - 21.9
High	≥ 22.0

Notes:

1. GTX's Soil Abrasivity Test is based on Nilsen, B., Dahl, F., Holzhäuser J., Raleigh P., New test methodology for estimating the abrasiveness of soils for TBM tunneling. proceeding of RETC conference 2007: 104- 116.
The trademarked acronyms and terms SATTM and Soil Abrasion TestTM are unique for test results and calculated indices originating from NTNU/SINTEF and can only be obtained by testing samples at their reference laboratory in Trondheim, Norway.
2. Abrasion test material was provided to GTX by client. The test material was dried at 30°C for 3-4 days until dry. The Soil Abrasion Test pieces are comprised of cutter ring steel.
3. Test was performed at 20 RPM for 1 minute for a total of 20 revolutions.

Client:	Tolunay-Wong Engineers, Inc.
Project Name:	FNI CoBMT Collier Raw Water Pump
Project Location:	Beaumont, TX
GTX #:	313650
Boring ID:	TB-5
Sample ID:	---
Depth, ft:	10.5-12

Soil Abrasivity Test - Sample As-Received



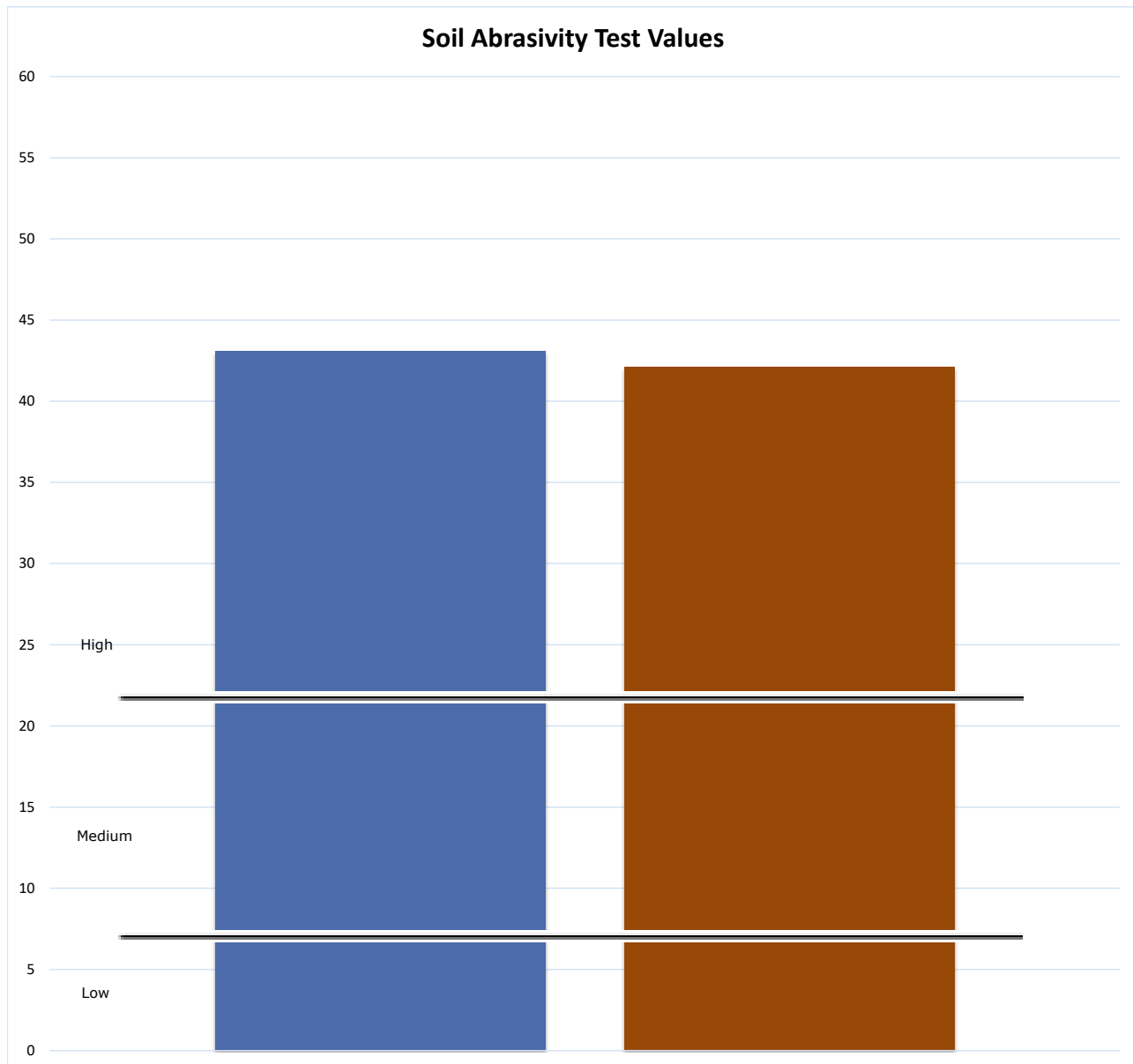
Notes:

1. GTX's Soil Abrasivity Test is based on Nilsen, B., Dahl, F., Holzhäuser J., Raleigh P., New test methodology for estimating the abrasiveness of soils for TBM tunneling. proceeding of RETC conference 2007: 104- 116. The trademarked acronyms and terms SAT™ and Soil Abrasion Test™ are unique for test results and calculated indices originating from NTNU/SINTEF and can only be obtained by testing samples at their reference laboratory in Trondheim, Norway.



Client:	Tolunay-Wong Engineers, Inc.
Project Name:	FNI CoBMT Collier Raw Water Pump
Project Location:	Beaumont, TX
GTX #:	313650
Test Date:	5/27/2021
Tested By:	tlm
Checked By:	jsc
Boring ID:	TB-5
Sample ID:	---
Depth, ft:	10.5-12

Soil Abrasivity Test



Notes: 1. GTX's Soil Abrasivity Test is based on Nilsen, B., Dahl, F., Holzhäuser J., Raleigh P., New test methodology for estimating the abrasiveness of soils for TBM tunneling. proceeding of RETC conference 2007: 104- 116.
The trademarked acronyms and terms SAT™ and Soil Abrasion Test™ are unique for test results and calculated indices originating from NTNU/SINTEF and can only be obtained by testing samples at their reference laboratory in Trondheim, Norway.

APPENDIX F

ELECTRICAL RESISTIVITY RESULTS

Tolunay-Wong Engineers, Inc.

2455 West Cardinal Drive, Suite A • Beaumont, Texas 77705 • Phone: (409) 840-4214 • Fax: (409) 840-4259

ERS-1 Electrical Resistivity Survey North-South						
Record Number	Electrode Spacing, a (ft)	Current (amps)	Measured Resistance, R (ohms)	Apparent Resistivity, ρ (ohm-ft)	Apparent Resistivity, ρ (ohm-m)	Apparent Resistivity, ρ (ohm-cm)
24	2.5	20	6.011	94.41	28.78	2877.68
23	2.5	20	5.967	93.73	28.57	2857.01
22	5	50	1.528	47.99	14.63	1462.74
21	5	50	1.526	47.94	14.61	1461.06
20	10	50	0.765	48.08	14.66	1465.57
19	10	50	0.765	48.10	14.66	1465.97
18	20	50	0.314	39.50	12.04	1203.93
17	20	50	0.314	39.49	12.04	1203.53
16	30	100	0.148	27.97	8.52	852.43
15	30	100	0.149	28.01	8.54	853.81

Notes:

1. Test procedure performed using Wenner Four-Electrode Method in general accordance with ASTM G 57.
2. Calibration measurements of 19.94 ohms (before test) and 19.94 (after test) with 19.93 ohm resistor.
Less than 5 percent tolerance.
3. Surface covering is dry crushed aggregate.
4. Instrument: Advanced Geosciences, Inc. MINISTING Resistivity meter. S/N: S1104289

Tolunay-Wong Engineers, Inc.

2455 West Cardinal Drive, Suite A • Beaumont, Texas 77705 • Phone: (409) 840-4214 • Fax: (409) 840-4259

ERS-1 Electrical Resistivity Survey East-West						
Record Number	Electrode Spacing, a (ft)	Current (amps)	Measured Resistance, R (ohms)	Apparent Resistivity, ρ (ohm-ft)	Apparent Resistivity, ρ (ohm-m)	Apparent Resistivity, ρ (ohm-cm)
12	2.5	20	6.835	107.36	32.72	3272.33
11	2.5	20	6.855	107.67	32.82	3281.78
10	5	20	2.820	88.58	27.00	2699.80
9	5	20	2.817	88.48	26.97	2696.96
8	10	20	1.146	71.97	21.94	2193.68
7	10	20	1.146	72.01	21.95	2194.83
6	20	20	0.474	59.61	18.17	1817.03
4	20	20	0.470	59.01	17.99	1798.62
3	30	20	0.237	44.68	13.62	1361.85
2	30	20	0.238	44.88	13.68	1367.79

Notes:

1. Test procedure performed using Wenner Four-Electrode Method in general accordance with ASTM G 57.
2. Calibration measurements of 19.93 ohms (before test) and 19.93 (after test) with 19.94 ohm resistor.
Less than 5 percent tolerance.
3. Surface covering is dry crushed aggregate.
4. Instrument: Advanced Geosciences, Inc. MINISTING Resistivity meter. S/N: S1104289

Tolunay-Wong Engineers, Inc.

2455 West Cardinal Drive, Suite A • Beaumont, Texas 77705 • Phone: (409) 840-4214 • Fax: (409) 840-4259

ERS-03 Electrical Resistivity Survey North-South						
Record Number	Electrode Spacing, a (ft)	Current (amps)	Measured Resistance, R (ohms)	Apparent Resistivity, ρ (ohm-ft)	Apparent Resistivity, ρ (ohm-m)	Apparent Resistivity, ρ (ohm-cm)
38	2.5	50	33.075	519.54	158.36	15835.58
37	2.5	50	33.080	519.62	158.38	15838.02
36	5	50	9.191	288.76	88.01	8801.40
35	5	50	9.193	288.80	88.03	8802.62
34	10	50	1.298	81.57	24.86	2486.16
33	10	50	1.298	81.58	24.86	2486.47
32	20	50	0.313	39.35	11.99	1199.39
31	20	50	0.313	39.34	11.99	1199.08
30	30	50	0.188	35.47	10.81	1081.22
29	30	50	0.190	35.87	10.93	1093.44
28	50	50	0.090	28.13	8.57	857.28
27	50	50	0.089	28.09	8.56	856.18

Notes:

1. Test procedure performed using Wenner Four-Electrode Method in general accordance with ASTM G 57.
2. Calibration measurements of 19.93 ohms (before test) and 19.93 (after test) with 19.93 ohm resistor.
Less than 5 percent tolerance.
3. Surface covering is dry grass, brush, trees and sand.
4. Instrument: Advanced Geosciences, Inc. MINISTING Resistivity meter. S/N: S1104289

Tolunay-Wong Engineers, Inc.

2455 West Cardinal Drive, Suite A • Beaumont, Texas 77705 • Phone: (409) 840-4214 • Fax: (409) 840-4259

ERS-03 Electrical Resistivity Survey East-West						
Record Number	Electrode Spacing, a (ft)	Current (amps)	Measured Resistance, R (ohms)	Apparent Resistivity, ρ (ohm-ft)	Apparent Resistivity, ρ (ohm-m)	Apparent Resistivity, ρ (ohm-cm)
52	2.5	100	9.731	152.85	46.59	4658.87
51	2.5	100	9.724	152.74	46.56	4655.52
50	5	100	3.243	101.87	31.05	3105.00
49	5	100	3.241	101.82	31.03	3103.47
48	10	100	1.199	75.30	22.95	2295.27
47	10	100	1.199	75.31	22.95	2295.36
46	20	50	0.505	63.45	19.34	1933.90
45	20	50	0.509	63.97	19.50	1949.78
44	30	50	0.299	56.45	17.21	1720.66
43	30	50	0.300	56.51	17.22	1722.36
42	50	50	0.130	40.93	12.48	1247.58
41	50	50	0.130	40.97	12.49	1248.61

Notes:

1. Test procedure performed using Wenner Four-Electrode Method in general accordance with ASTM G 57.
2. Calibration measurements of 19.94 ohms (before test) and 19.93 (after test) with 19.93 ohm resistor.
Less than 5 percent tolerance.
3. Surface covering is dry grass, brush, trees and sand.
4. Instrument: Advanced Geosciences, Inc. MINISTING Resistivity meter. S/N: S1104289

Tolunay-Wong Engineers, Inc.

2455 West Cardinal Drive, Suite A • Beaumont, Texas 77705 • Phone: (409) 840-4214 • Fax: (409) 840-4259

ERS-05 Electrical Resistivity Survey North-South						
Record Number	Electrode Spacing, a (ft)	Current (amps)	Measured Resistance, R (ohms)	Apparent Resistivity, ρ (ohm-ft)	Apparent Resistivity, ρ (ohm-m)	Apparent Resistivity, ρ (ohm-cm)
67	2.5	50	27.365	429.84	131.02	13101.52
66	2.5	50	27.360	429.76	130.99	13099.08
65	5	50	6.409	201.34	61.37	6136.84
64	5	50	6.409	201.33	61.37	6136.54
63	10	50	2.259	141.94	43.26	4326.33
62	10	50	2.259	141.96	43.27	4326.94
61	20	20	0.580	72.89	22.22	2221.60
60	20	20	0.582	73.15	22.30	2229.70
58	30	10	0.340	64.00	19.51	1950.69
57	30	10	0.343	64.58	19.68	1968.28
56	50	100	0.119	37.44	11.41	1141.11
55	50	100	0.119	37.44	11.41	1141.14

Notes:

1. Test procedure performed using Wenner Four-Electrode Method in general accordance with ASTM G 57.
2. Calibration measurements of 19.93 ohms (before test) and 19.93 (after test) with 19.93 ohm resistor.
Less than 5 percent tolerance.
3. Surface covering is dry sand and trees.
4. Instrument: Advanced Geosciences, Inc. MINISTING Resistivity meter. S/N: S1104289

Tolunay-Wong Engineers, Inc.

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ERS-05 Electrical Resistivity Survey East-West						
Record Number	Electrode Spacing, a (ft)	Current (amps)	Measured Resistance, R (ohms)	Apparent Resistivity, ρ (ohm-ft)	Apparent Resistivity, ρ (ohm-m)	Apparent Resistivity, ρ (ohm-cm)
81	2.5	100	14.330	225.10	68.61	6861.05
80	2.5	100	14.332	225.12	68.62	6861.66
79	5	100	6.878	216.06	65.86	6585.51
78	5	100	6.879	216.10	65.87	6586.73
77	10	100	2.648	166.38	50.71	5071.26
76	10	100	2.648	166.40	50.72	5071.87
75	20	50	0.959	120.56	36.75	3674.67
74	20	50	0.960	120.58	36.75	3675.28
73	30	100	0.313	59.00	17.98	1798.17
72	30	100	0.313	59.02	17.99	1798.87
71	50	100	0.110	34.45	10.50	1049.94
70	50	100	0.110	34.46	10.50	1050.31

Notes:

1. Test procedure performed using Wenner Four-Electrode Method in general accordance with ASTM G 57.
2. Calibration measurements of 19.93 ohms (before test) and 19.93 (after test) with 19.93 ohm resistor.
Less than 5 percent tolerance.
3. Surface covering is dry grass, trees and sand.
4. Instrument: Advanced Geosciences, Inc. MINISTING Resistivity meter. S/N: S1104289

Tolunay-Wong Engineers, Inc.

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ERS-07 Electrical Resistivity Survey North-South						
Record Number	Electrode Spacing, a (ft)	Current (amps)	Measured Resistance, R (ohms)	Apparent Resistivity, ρ (ohm-ft)	Apparent Resistivity, ρ (ohm-m)	Apparent Resistivity, ρ (ohm-cm)
95	2.5	100	17.837	280.19	85.40	8540.19
94	2.5	100	17.841	280.25	85.42	8542.02
93	5	50	2.812	88.35	26.93	2692.88
92	5	50	2.811	88.32	26.92	2691.93
91	10	10	0.640	40.20	12.25	1225.27
90	10	10	0.641	40.27	12.27	1227.40
89	20	100	0.312	39.19	11.95	1194.54
88	20	100	0.312	39.19	11.94	1194.48
87	30	100	0.209	39.41	12.01	1201.22
86	30	100	0.209	39.40	12.01	1200.79
85	50	50	0.091	28.63	8.73	872.64
84	50	50	0.091	28.58	8.71	871.15

Notes:

1. Test procedure performed using Wenner Four-Electrode Method in general accordance with ASTM G 57.
2. Calibration measurements of 19.93 ohms (before test) and 19.93 (after test) with 19.93 ohm resistor.
Less than 5 percent tolerance.
3. Surface covering is perched water with sand, trees and brush.
4. Instrument: Advanced Geosciences, Inc. MINISTING Resistivity meter. S/N: S1104289

Tolunay-Wong Engineers, Inc.

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ERS-07 Electrical Resistivity Survey East-West						
Record Number	Electrode Spacing, a (ft)	Current (amps)	Measured Resistance, R (ohms)	Apparent Resistivity, ρ (ohm-ft)	Apparent Resistivity, ρ (ohm-m)	Apparent Resistivity, ρ (ohm-cm)
109	2.5	100	11.952	187.74	57.22	5722.32
108	2.5	100	11.953	187.76	57.23	5722.92
107	5	100	3.606	113.30	34.53	3453.38
106	5	100	3.606	113.27	34.52	3452.47
105	10	50	0.804	50.54	15.40	1540.34
104	10	50	0.803	50.46	15.38	1538.02
103	20	100	0.326	40.97	12.49	1248.80
102	20	100	0.326	40.97	12.49	1248.80
101	30	100	0.209	39.47	12.03	1203.08
100	30	100	0.209	39.43	12.02	1201.77
99	50	20	0.095	29.89	9.11	911.02
98	50	20	0.094	29.63	9.03	903.03

Notes:

1. Test procedure performed using Wenner Four-Electrode Method in general accordance with ASTM G 57.
2. Calibration measurements of 19.93 ohms (before test) and 19.93 (after test) with 19.93 ohm resistor.
Less than 5 percent tolerance.
3. Surface covering is perched water with sand, brush and trees.
4. Instrument: Advanced Geosciences, Inc. MINISTING Resistivity meter. S/N: S1104289

Tolunay-Wong Engineers, Inc.

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ERS-08 Electrical Resistivity Survey North-South						
Record Number	Electrode Spacing, a (ft)	Current (amps)	Measured Resistance, R (ohms)	Apparent Resistivity, ρ (ohm-ft)	Apparent Resistivity, ρ (ohm-m)	Apparent Resistivity, ρ (ohm-cm)
138	2.5	50	22.712	356.75	108.74	10873.74
137	2.5	50	22.696	356.51	108.66	10866.42
136	5	50	3.482	109.38	33.34	3333.90
135	5	50	3.445	108.23	32.99	3298.85
134	10	50	0.639	40.14	12.23	1223.47
133	10	50	0.642	40.31	12.29	1228.74
132	20	50	0.203	25.49	7.77	776.78
131	20	50	0.206	25.86	7.88	788.15
130	30	50	0.138	26.05	7.94	794.03
129	30	50	0.139	26.15	7.97	797.05
128	50	20	0.062	19.52	5.95	594.91
127	50	20	0.061	19.32	5.89	588.78

Notes:

1. Test procedure performed using Wenner Four-Electrode Method in general accordance with ASTM G 57.
2. Calibration measurements of 19.93 ohms (before test) and 19.93 (after test) with 19.93 ohm resistor.
Less than 5 percent tolerance.
3. Surface covering is moist with sand, trees and brush.
4. Instrument: Advanced Geosciences, Inc. MINISTING Resistivity meter. S/N: S1104289

Tolunay-Wong Engineers, Inc.

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ERS-08 Electrical Resistivity Survey East-West						
Record Number	Electrode Spacing, a (ft)	Current (amps)	Measured Resistance, R (ohms)	Apparent Resistivity, ρ (ohm-ft)	Apparent Resistivity, ρ (ohm-m)	Apparent Resistivity, ρ (ohm-cm)
124	2.5	50	19.312	303.35	92.46	9246.11
123	2.5	50	19.323	303.52	92.51	9251.29
122	5	50	6.186	194.34	59.23	5923.48
121	5	50	6.183	194.23	59.20	5920.13
119	10	50	0.883	55.46	16.90	1690.36
118	10	50	0.883	55.45	16.90	1690.18
117	20	100	0.253	31.75	9.68	967.86
116	20	100	0.252	31.66	9.65	965.00
115	30	100	0.171	32.29	9.84	984.23
114	30	100	0.171	32.26	9.83	983.25
113	50	100	0.091	28.48	8.68	868.13
112	50	100	0.091	28.56	8.70	870.39

Notes:

1. Test procedure performed using Wenner Four-Electrode Method in general accordance with ASTM G 57.
2. Calibration measurements of 19.93 ohms (before test) and 19.93 (after test) with 19.93 ohm resistor.
Less than 5 percent tolerance.
3. Surface covering is moist with sand, brush and trees.
4. Instrument: Advanced Geosciences, Inc. MINISTING Resistivity meter. S/N: S1104289

Tolunay-Wong Engineers, Inc.

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ERS-10 Electrical Resistivity Survey North-South						
Record Number	Electrode Spacing, a (ft)	Current (amps)	Measured Resistance, R (ohms)	Apparent Resistivity, ρ (ohm-ft)	Apparent Resistivity, ρ (ohm-m)	Apparent Resistivity, ρ (ohm-cm)
172	2.5	200	4.134	64.94	19.79	1979.46
171	2.5	200	4.131	64.89	19.78	1977.97
170	5	50	1.795	56.39	17.19	1718.89
169	5	50	1.796	56.42	17.20	1719.65
166	10	100	0.899	56.47	17.21	1721.24
165	10	100	0.899	56.48	17.21	1721.42
159	20	100	0.456	57.36	17.48	1748.33
158	20	100	0.456	57.32	17.47	1746.96
157	30	100	0.261	49.22	15.00	1500.23
156	30	100	0.268	50.49	15.39	1539.03
155	50	100	0.142	44.60	13.59	1359.35
154	50	100	0.143	44.85	13.67	1367.12

Notes:

1. Test procedure performed using Wenner Four-Electrode Method in general accordance with ASTM G 57.
2. Calibration measurements of 19.93 ohms (before test) and 19.93 (after test) with 19.93 ohm resistor.
Less than 5 percent tolerance.
3. Surface covering is saturated brush and trees.
4. Instrument: Advanced Geosciences, Inc. MINISTING Resistivity meter. S/N: S1104289

Tolunay-Wong Engineers, Inc.

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ERS-10 Electrical Resistivity Survey East-West						
Record Number	Electrode Spacing, a (ft)	Current (amps)	Measured Resistance, R (ohms)	Apparent Resistivity, ρ (ohm-ft)	Apparent Resistivity, ρ (ohm-m)	Apparent Resistivity, ρ (ohm-cm)
152	2.5	100	3.941	61.90	18.87	1886.71
151	2.5	100	3.937	61.85	18.85	1885.13
150	5	100	1.722	54.11	16.49	1649.21
149	5	100	1.717	53.93	16.44	1643.82
148	10	200	1.039	65.27	19.89	1989.28
147	10	200	1.038	65.24	19.89	1988.55
146	20	100	0.528	66.32	20.21	2021.40
145	20	100	0.527	66.28	20.20	2020.21
144	30	100	0.343	64.68	19.72	1971.51
143	30	100	0.336	63.31	19.30	1929.78
142	50	100	0.144	45.29	13.80	1380.29
141	50	100	0.145	45.63	13.91	1390.68

Notes:

1. Test procedure performed using Wenner Four-Electrode Method in general accordance with ASTM G 57.
2. Calibration measurements of 19.93 ohms (before test) and 19.93 (after test) with 19.93 ohm resistor.
Less than 5 percent tolerance.
3. Surface covering is perched water and crushed aggregate.
4. Instrument: Advanced Geosciences, Inc. MINISTING Resistivity meter. S/N: S1104289

Tolunay-Wong Engineers, Inc.

2455 West Cardinal Drive, Suite A • Beaumont, Texas 77705 • Phone: (409) 840-4214 • Fax: (409) 840-4259

ERS-11 Electrical Resistivity Survey North-South						
Record Number	Electrode Spacing, a (ft)	Current (amps)	Measured Resistance, R (ohms)	Apparent Resistivity, ρ (ohm-ft)	Apparent Resistivity, ρ (ohm-m)	Apparent Resistivity, ρ (ohm-cm)
185	2.5	200	3.886	61.04	18.60	1860.47
184	2.5	200	3.884	61.01	18.60	1859.68
183	5	200	1.728	54.29	16.55	1654.82
182	5	200	1.727	54.27	16.54	1654.00
181	10	200	0.658	41.36	12.61	1260.74
180	10	200	0.659	41.41	12.62	1262.30
179	20	200	0.297	37.37	11.39	1139.01
178	20	200	0.298	37.40	11.40	1140.07
177	30	200	0.158	29.81	9.08	908.49
176	30	200	0.158	29.80	9.08	908.15
175	50	200	0.081	25.31	7.72	771.51
174	50	200	0.081	25.31	7.72	771.54

Notes:

1. Test procedure performed using Wenner Four-Electrode Method in general accordance with ASTM G 57.
2. Calibration measurements of 19.93 ohms (before test) and 19.93 (after test) with 19.93 ohm resistor.
Less than 5 percent tolerance.
3. Surface covering is saturated grass.
4. Instrument: Advanced Geosciences, Inc. MINISTING Resistivity meter. S/N: S1104289

Tolunay-Wong Engineers, Inc.

2455 West Cardinal Drive, Suite A • Beaumont, Texas 77705 • Phone: (409) 840-4214 • Fax: (409) 840-4259

ERS-11 Electrical Resistivity Survey East-West						
Record Number	Electrode Spacing, a (ft)	Current (amps)	Measured Resistance, R (ohms)	Apparent Resistivity, ρ (ohm-ft)	Apparent Resistivity, ρ (ohm-m)	Apparent Resistivity, ρ (ohm-cm)
200	2.5	200	2.774	43.57	13.28	1327.98
199	2.5	200	2.769	43.49	13.26	1325.67
198	5	200	1.367	42.93	13.09	1308.60
197	5	200	1.364	42.86	13.06	1306.49
196	10	200	0.614	38.60	11.76	1176.47
195	10	200	0.614	38.59	11.76	1176.22
194	20	200	0.296	37.15	11.32	1132.18
193	20	200	0.296	37.15	11.32	1132.39
192	30	200	0.174	32.74	9.98	998.04
191	30	200	0.174	32.75	9.98	998.31
190	50	200	0.078	24.37	7.43	742.86
189	50	200	0.078	24.39	7.44	743.53

Notes:

1. Test procedure performed using Wenner Four-Electrode Method in general accordance with ASTM G 57.
2. Calibration measurements of 19.93 ohms (before test) and 19.93 (after test) with 19.93 ohm resistor.
Less than 5 percent tolerance.
3. Surface covering is saturated grass.
4. Instrument: Advanced Geosciences, Inc. MINISTING Resistivity meter. S/N: S1104289

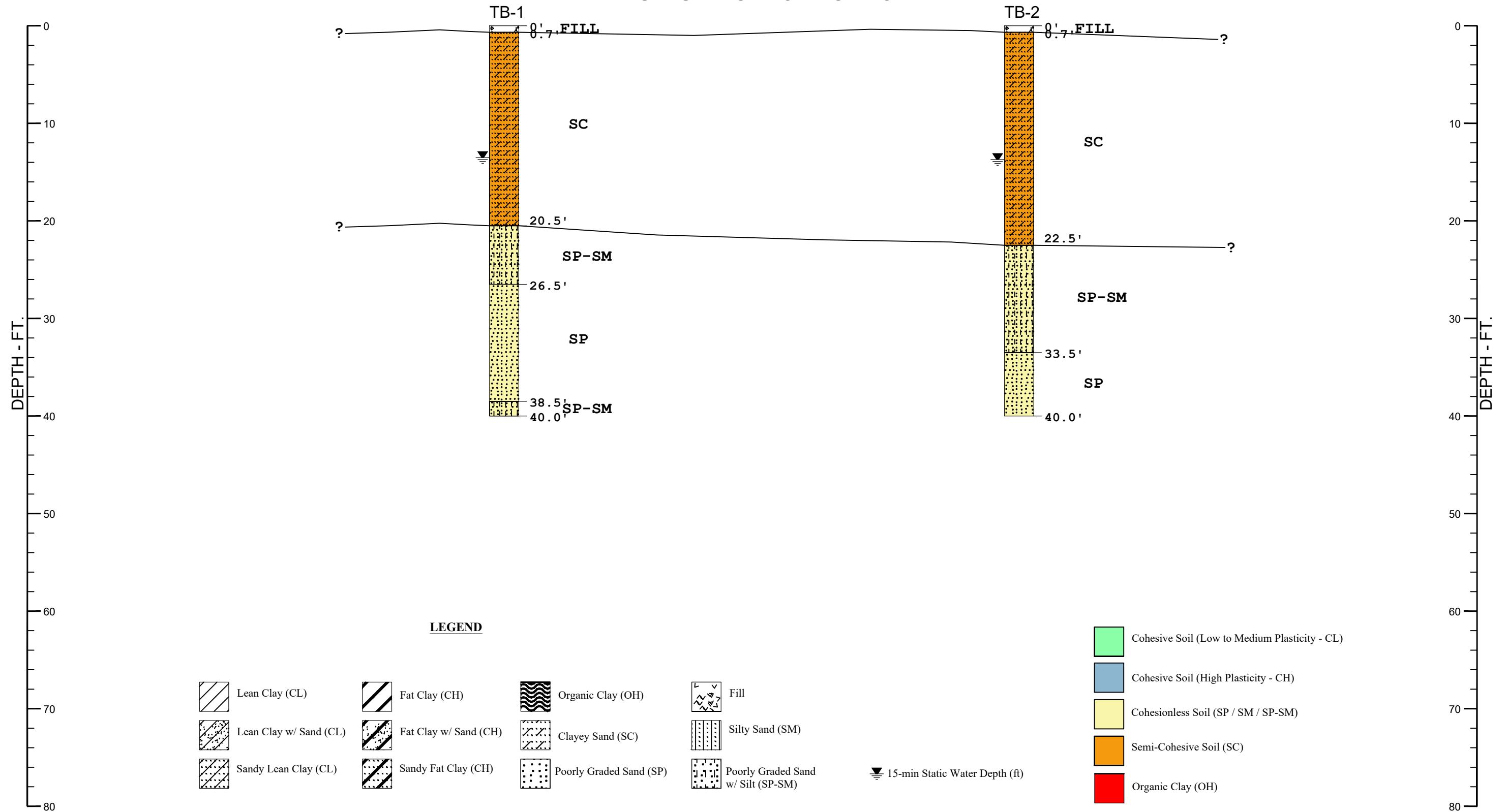
APPENDIX G

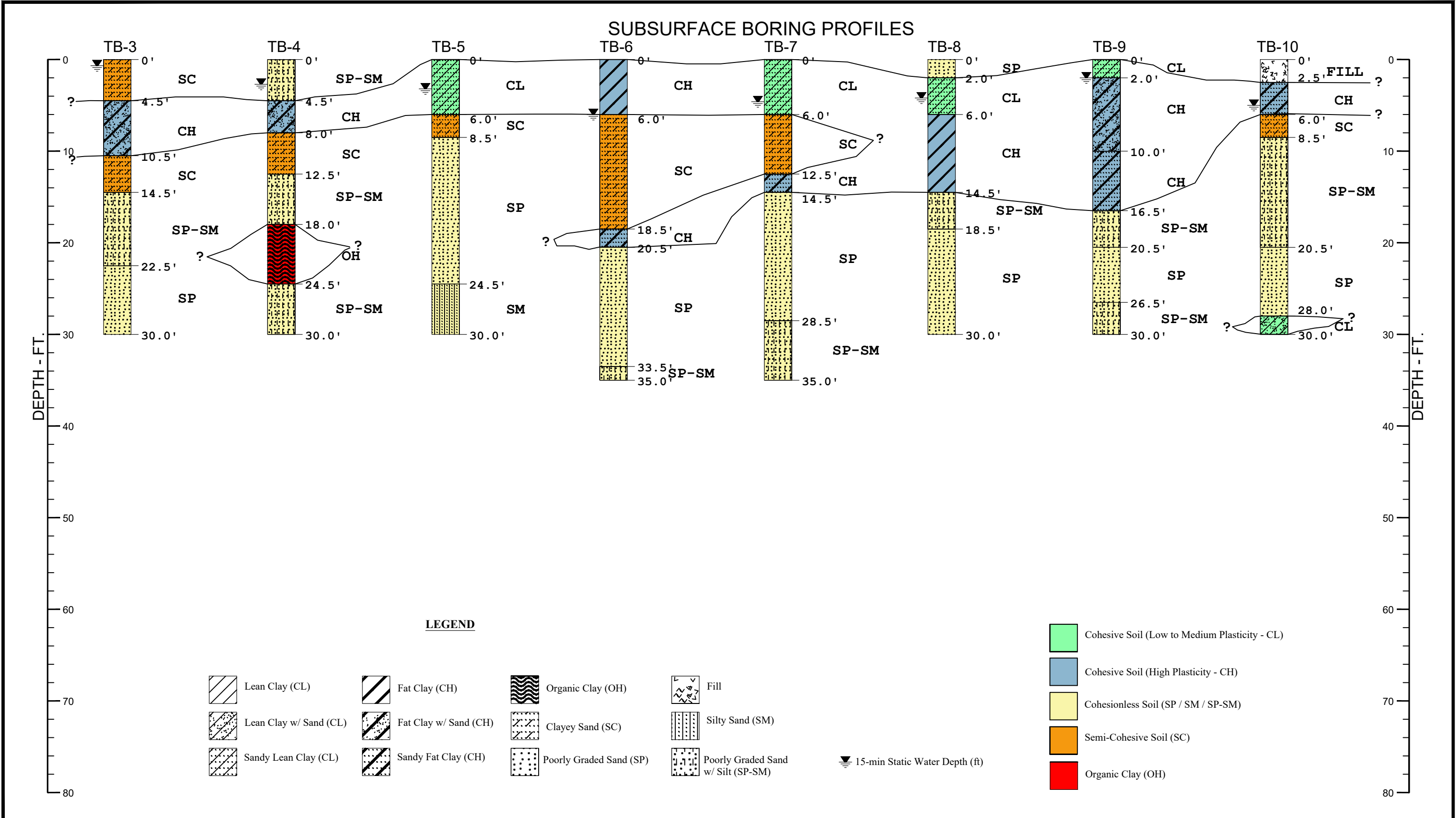
CROSS-SECTIONAL SUBSURFACE PROFILES

COLLIER RAW WATER PUMP STATION AND TUNNEL
BEAUMONT, TEXAS

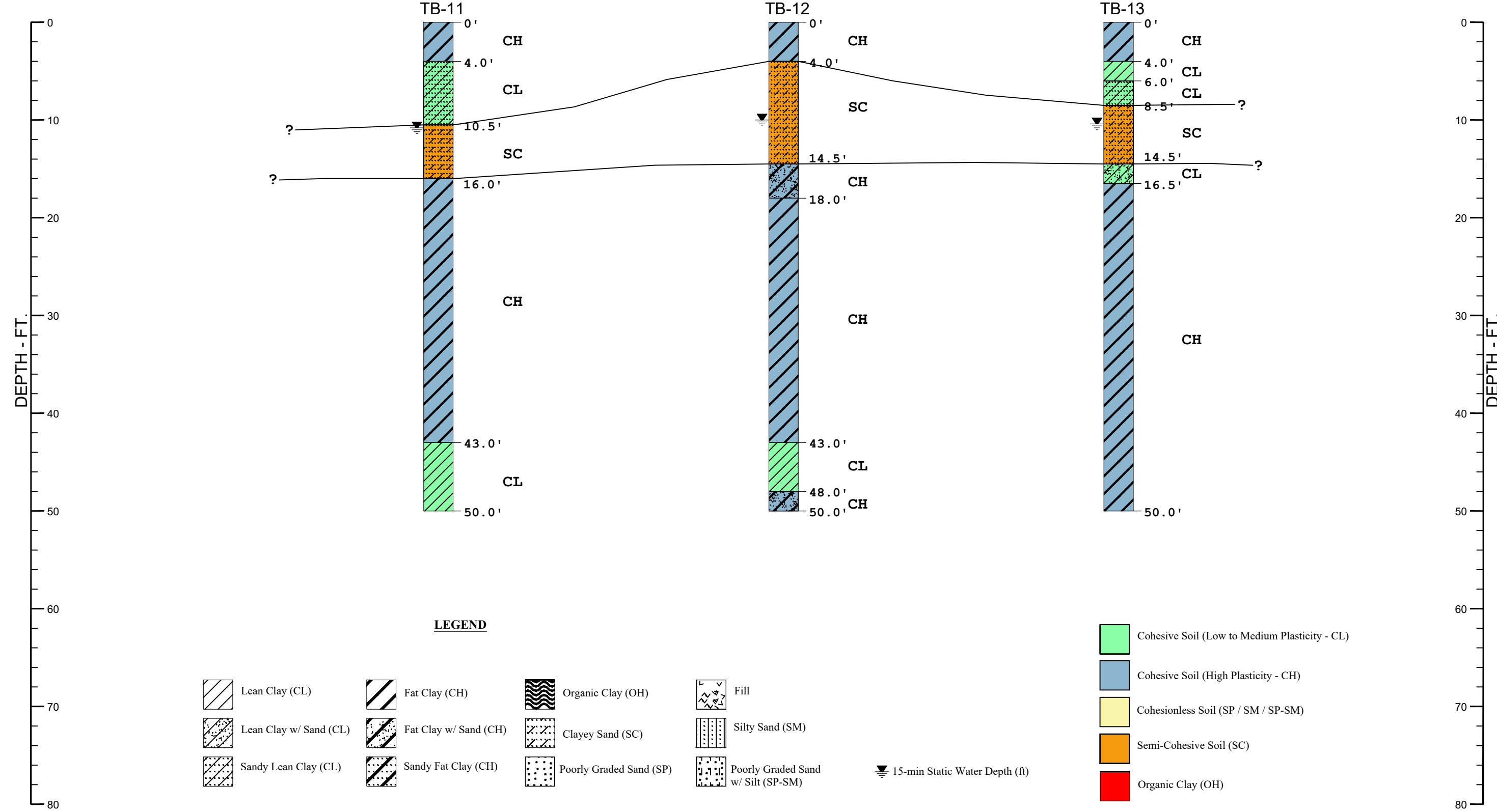
LAWSON PUMP STATION SUBSURFACE BORING PROFILES

FIGURE 1





SUBSURFACE BORING PROFILES



COLLIER RAW WATER PUMP STATION AND TUNNEL
BEAUMONT, TEXAS

FREESE AND NICHOLS, INC.
PEARLAND, TEXAS



COLLIER RAW WATER PUMP STATION
SUBSURFACE BORING PROFILES

PROJECT NO.: 21.23.014

FIGURE 3

APPENDIX H


SLUG TEST REPORTS

SLUG TEST PZ-2 29.5-ft

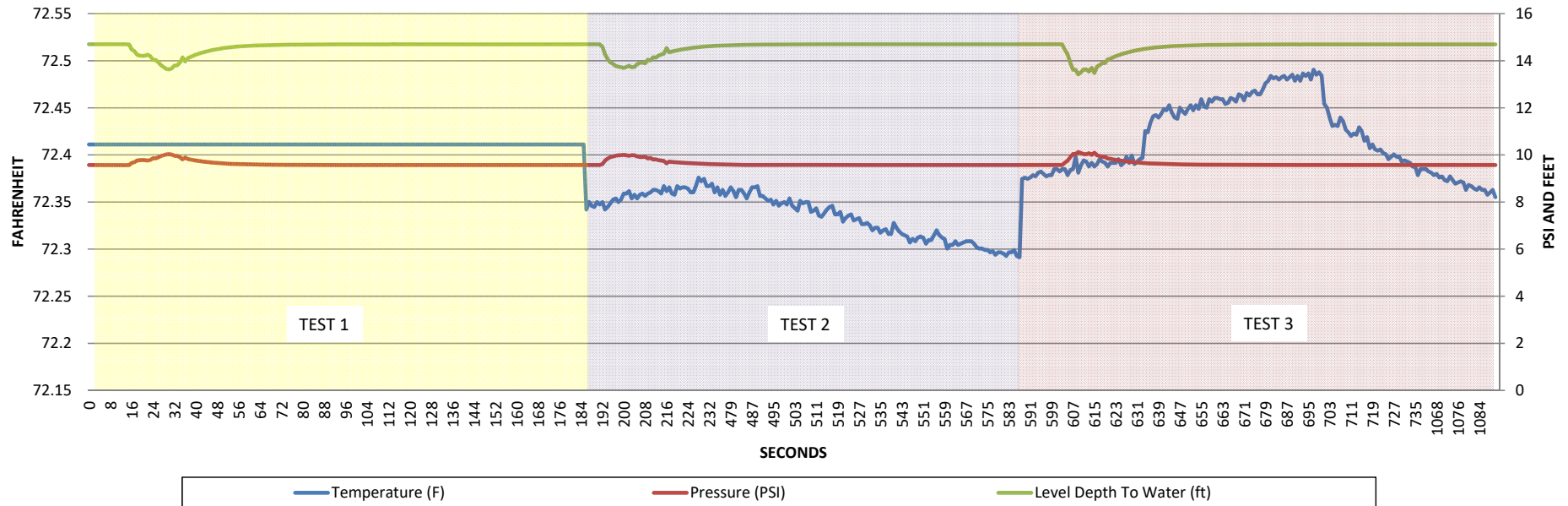


NOTES:

- 1) Three (3) slug tests were performed at PZ-2 at a depth of 29.5-ft below grade (top of screen) on February 26, 2021.
- 2) PZ-2 water level reading was 12.0-ft below grade prior to slug testing.
- 3) PZ-2 total depth of 40-ft below grade. PZ-2 screened from 30-ft to 40-ft below grade.


Project Collier Raw Water Pump Station and Tunnel Beaumont, Texas	 Tolunay-Wong Engineers, Inc.	Project No. 21.23.014 Report No. 120334
Client Freese and Nichols, Inc. Pearland, Texas	Slug Test PZ-2 (29.5-ft)	Appendix H Figure 1

SLUG TEST PZ-2 32.5-ft

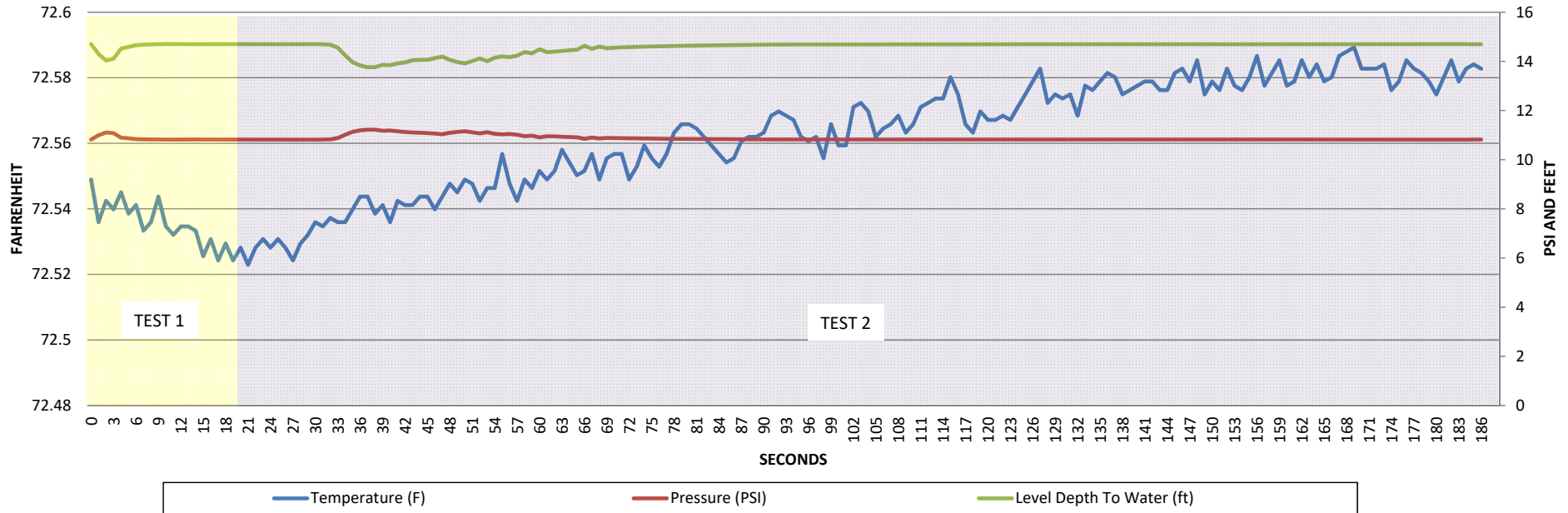


NOTES:

- 1) Three (3) slug tests were performed at PZ-2 at a depth of 32.5-ft below grade (upper section of screen) on February 26, 2021.
- 2) PZ-2 water level reading was 12.0-ft below grade prior to slug testing.
- 3) PZ-2 total depth of 40-ft below grade. PZ-2 screened from 30-ft to 40-ft below grade.


Project Collier Raw Water Pump Station and Tunnel Beaumont, Texas	 Tolunay-Wong Engineers, Inc.	Project No. 21.23.014 Report No. 120334
Client Freese and Nichols, Inc. Pearland, Texas	Slug Test PZ-2 (32.5-ft)	Appendix H Figure 2

SLUG TEST PZ-2 35.5-ft

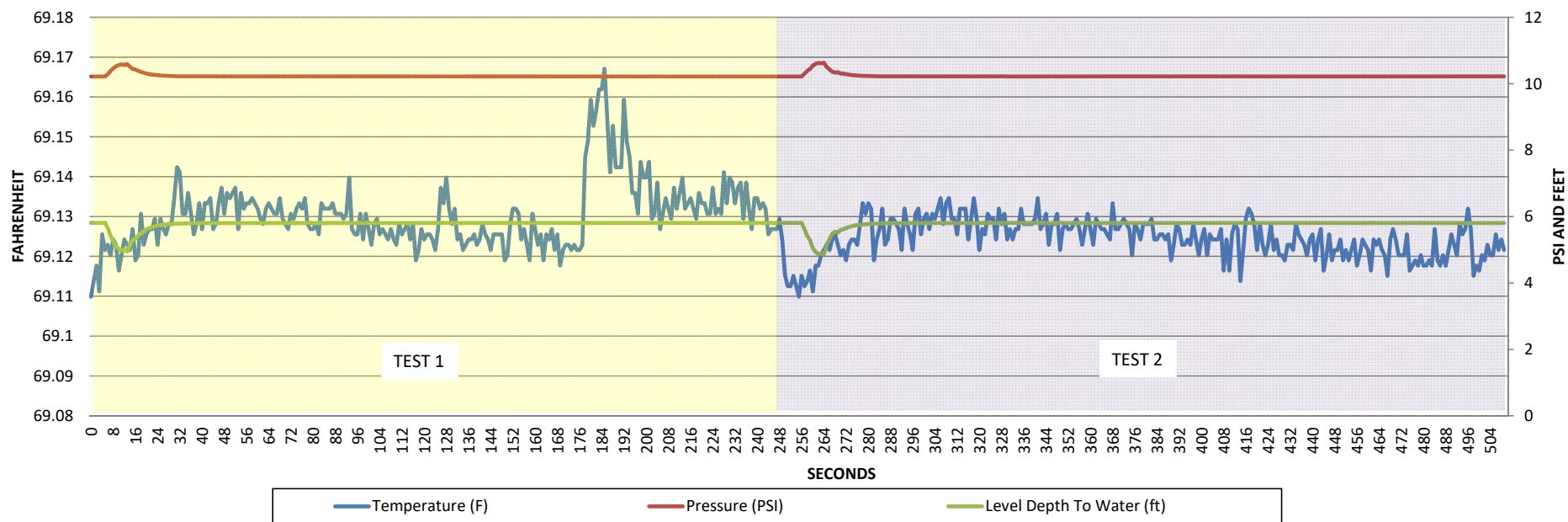


NOTES:

- 1) Two (2) slug tests were performed at PZ-2 at a depth of 35.5-ft below grade (mid-section of screen) on February 26, 2021.
- 2) PZ-2 water level reading was 12.0-ft below grade prior to slug testing.
- 3) PZ-2 total depth of 40-ft below grade. PZ-2 screened from 30-ft to 40-ft below grade.


Project Collier Raw Water Pump Station and Tunnel Beaumont, Texas	 Tolunay-Wong Engineers, Inc.	Project No. 21.23.014 Report No. 120334
Client Freese and Nichols, Inc. Pearland, Texas	Slug Test PZ-2 (35.5-ft)	Appendix H Figure 3

SLUG TEST PZ-7 27-ft

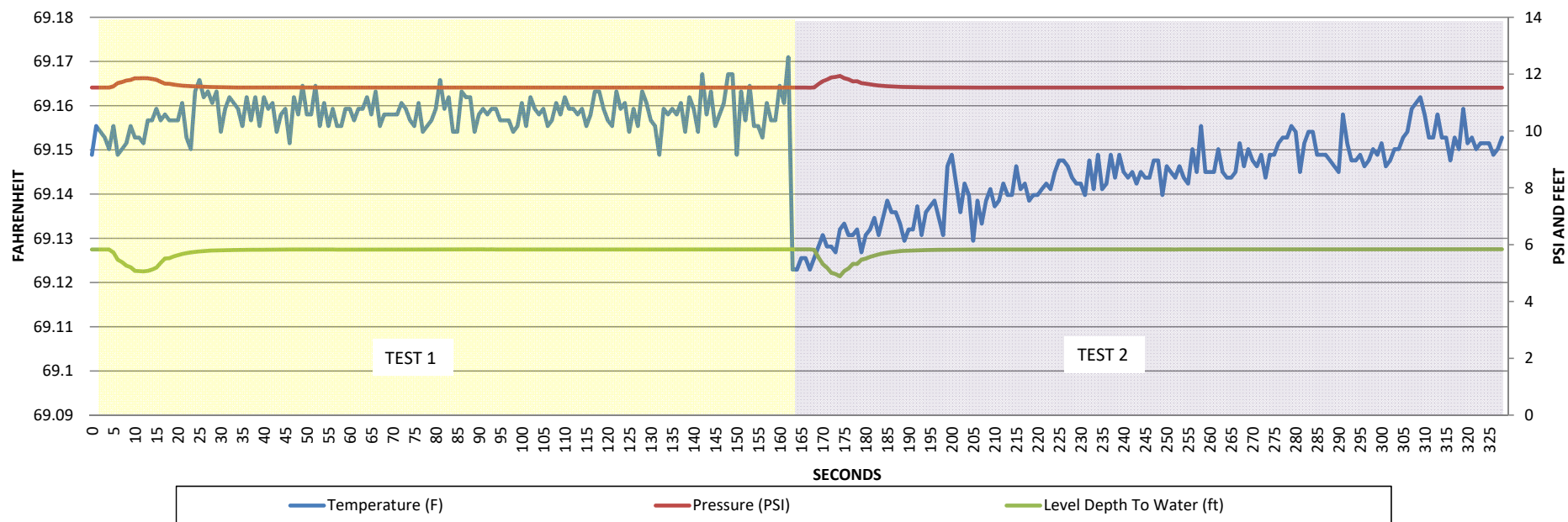


NOTES:

- 1) Two (2) slug tests were performed at PZ-7 at a depth of 27-ft below grade (upper section of screen) on March 11, 2021.
- 2) PZ-7 water level reading was 5.8-ft below grade prior to slug testing.
- 3) PZ-7 total depth of 35-ft below grade. PZ-7 screened from 25-ft to 35-ft below grade.


Project Collier Raw Water Pump Station and Tunnel Beaumont, Texas	 Tolunay-Wong Engineers, Inc.	Project No. 21.23.014 Report No. 120334
Client Freese and Nichols, Inc. Pearland, Texas	Slug Test PZ-7 (27-ft)	Appendix H Figure 4

SLUG TEST PZ-7 30-ft

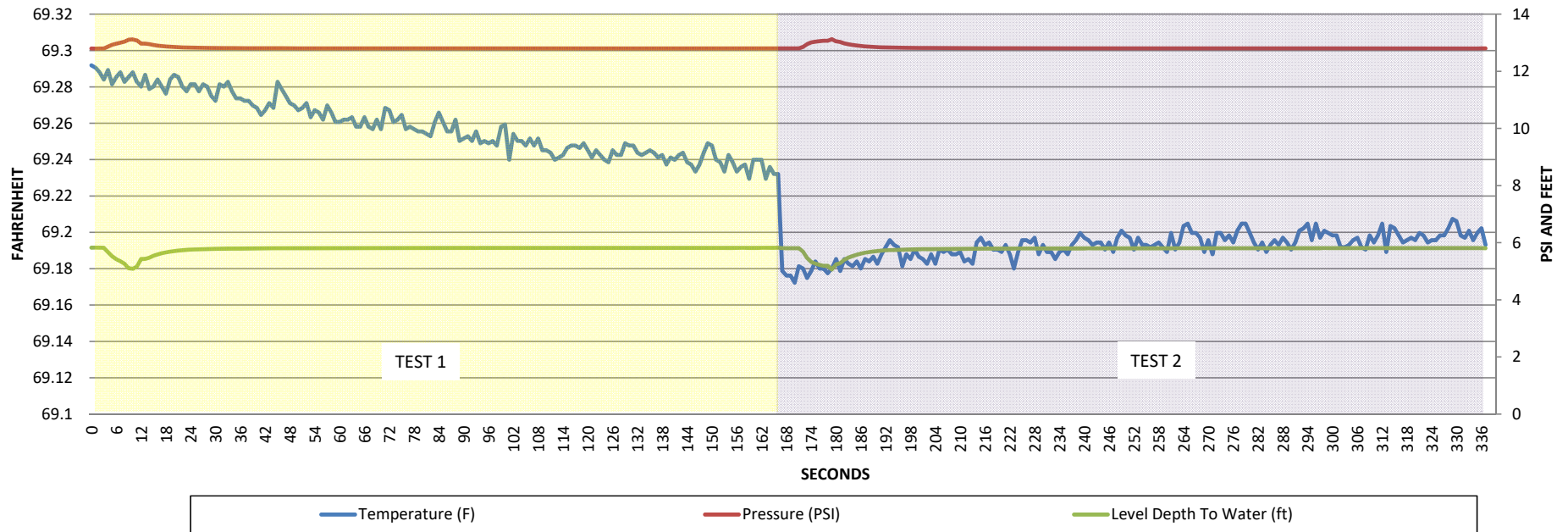


NOTES:

- 1) Two (2) slug tests were performed at PZ-7 at a depth of 30-ft below grade (mid-section of screen) on March 11, 2021.
- 2) PZ-7 water level reading was 5.8-ft below grade prior to slug testing.
- 3) PZ-7 total depth of 35-ft below grade. PZ-7 screened from 25-ft to 35-ft below grade.


Project Collier Raw Water Pump Station and Tunnel Beaumont, Texas	 Tolunay-Wong Engineers, Inc.	Project No. 21.23.014 Report No. 120334
Client Freese and Nichols, Inc. Pearland, Texas	Slug Test PZ-7 (30-ft)	Appendix H Figure 5

SLUG TEST PZ-7 33-ft

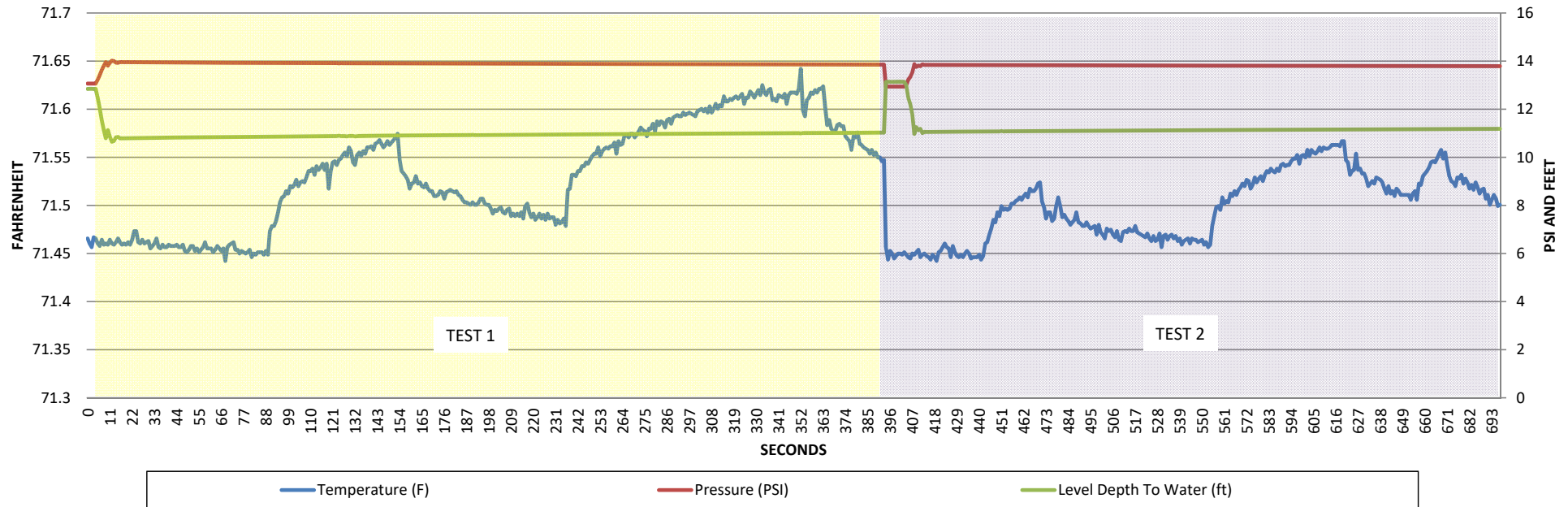


NOTES:

- 1) Two (2) slug tests were performed at PZ-7 at a depth of 33-ft below grade (bottom section of screen) on March 11, 2021.
- 2) PZ-7 water level reading was 5.8-ft below grade prior to slug testing.
- 3) PZ-7 total depth of 35-ft below grade. PZ-7 screened from 25-ft to 35-ft below grade.


Project Collier Raw Water Pump Station and Tunnel Beaumont, Texas	 Tolunay-Wong Engineers, Inc.	Project No. 21.23.014 Report No. 120334
Client Freese and Nichols, Inc. Pearland, Texas	Slug Test PZ-7 (33-ft)	Appendix H Figure 6

SLUG TEST PZ-13 42-ft

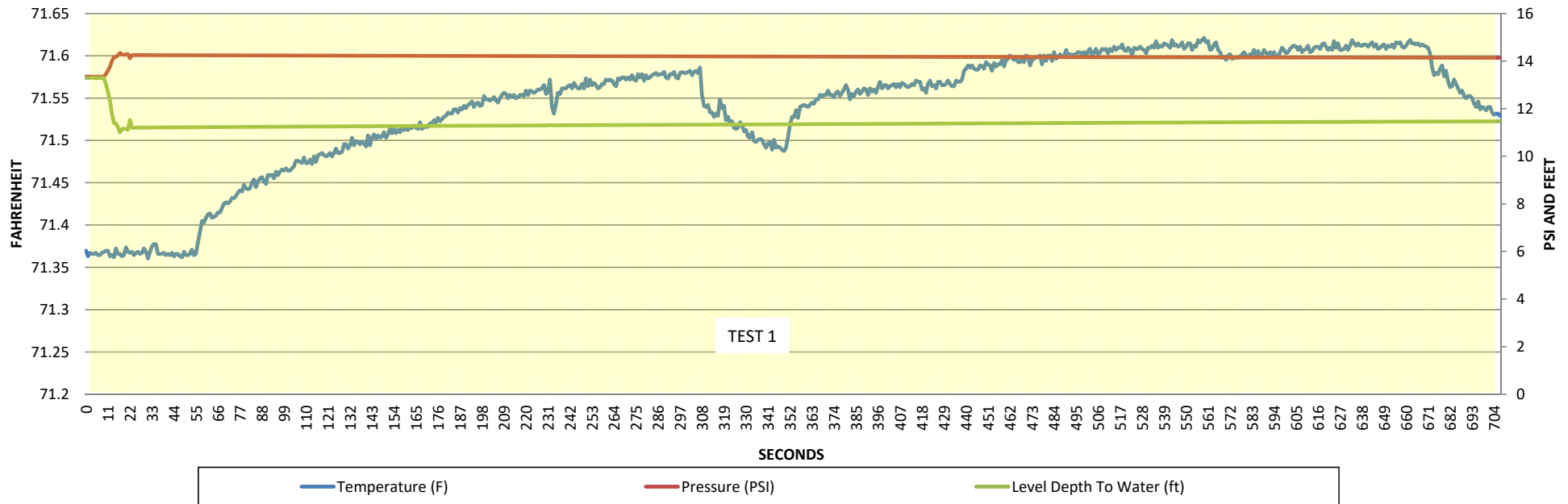


NOTES:

- 1) Two (2) slug tests were performed at PZ-13 at a depth of 42-ft below grade (upper section of screen) on March 11, 2021.
- 2) PZ-13 water level reading was 13.2-ft below grade prior to slug testing.
- 3) PZ-13 total depth of 50-ft below grade. PZ-13 screened from 40-ft to 50-ft below grade.


Project Collier Raw Water Pump Station and Tunnel Beaumont, Texas	 Tolunay-Wong Engineers, Inc.	Project No. 21.23.014 Report No. 120334
Client Freese and Nichols, Inc. Pearland, Texas	Slug Test PZ-13 (42-ft)	Appendix H Figure 7

SLUG TEST PZ-13 43-ft



NOTES:

- 1) One (1) slug tests was performed at PZ-13 at a depth of 43-ft below grade (mid-section of screen) on March 11, 2021.
- 2) PZ-13 water level reading was 13.2-ft below grade prior to slug testing.
- 3) PZ-13 total depth of 50-ft below grade. PZ-13 screened from 40-ft to 50-ft below grade.

Project Collier Raw Water Pump Station and Tunnel Beaumont, Texas	 Tolunay-Wong Engineers, Inc.	Project No. 21.23.014 Report No. 120334
Client Freese and Nichols, Inc. Pearland, Texas	Slug Test PZ-13 (43-ft)	Appendix H Figure 8